B.C. Hydro

Columbia River Murphy Creek Project

Preliminary summary
of principal impacts
and mitigation opportunities

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COLUMBIA RIVER
MURPHY CREEK PROJECT
PRELIMINARY SUMMARY OF PRINCIPAL IMPACTS AND
MITIGATION OPPORTUNITIES

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PREFACE

This Preliminary Summary Report forms part of an ongoing process of open planning with the public and government agencies and has been structured in two parts: Part I contains an overview of the project that has been prepared on the basis of the current Engineering Description. The report has been prepared to update, as far as possible, the details of the project as currently proposed although it should be noted that as the design advances further changes could result.

Part II contains summaries of studies of environmental and socio-economic impacts, and engineering studies covering noise, camp, infra-structure, groundwater and reservoir shoreline impacts; and mitigation opportunities proposed by the studies.

A series of public consultation meetings based on this report are planned. The results of these meetings together with all previous meetings will make up a portion of the application to the Ministry of Energy for an Energy Project Certificate for the Keenleyside-Murphy Project in accordance with the Utilities Commission Act.

The detailed environmental and engineering impact reports from which this report is drawn will be made publicly available after they are finalized.

Additional summary reports will be issued for the Keenleyside Powerplant Project and the Transmission Project.

PART I - THE PROJECT
SECTION 1.0 - INTRODUCTION

The proposed Murphy Creek Project is located on the Columbia River about 3 km upstream of the City of Trail, 23 km downstream of the confluence of the Columbia and Kootenay rivers and 33.7 km downstream of the Hugh Keenleyside Dam on the Columbia River.

Under the terms of the Columbia River Treaty between Canada and the United States three dams were constructed in Canada. The Mica and Hugh Keenleyside dams were constructed on the Columbia River in Canada and the Duncan Dam was constructed on the Duncan River, a tributary of Kootenay Lake. In the United States the Libby Dam was constructed on the Kootenai River. These dams provide river regulation that facilitates the feasibility of the Murphy Creek Project.

The Murphy Creek Project with reservoir at El. 424 m would raise the Columbia River about 15 m at the project site and flood low terrace land upstream to Castlegar. The stability of the reservoir shoreline and the effect of the reservoir on adjacent properties have been key factors in establishing the reservoir levels for normal operation and flood conditions. The project would develop a maximum gross head of about 18 m between the project site and Hugh Keenleyside Dam; the minimum gross head would be 7 m. The project would add 300 MW of capacity to the B.C. Hydro system.

Prefeasibility and feasibility studies for the Murphy Creek Project were carried out between 1978 and 1980.[1] Preliminary design studies commenced in 1981. The Phase 1 preliminary design study of this project has included field investigations and office studies. The study has advanced sufficiently to permit preliminary decisions to be reached on

the following project features and to allow a project cost estimate to be prepared.

1. Reservoir level.

2. Arrangement of structures.

3. Powerhouse arrangement and type of generating units.

4. Installed generating capacity and number of units.

5. Spillway type and hydraulic capacity.

6. Method and hydraulic capacity of river diversion during construction.

7. Type of embankment dam and seepage cut-off.

During the subsequent Phase 2 of preliminary design, all major project components will be optimized.

SECTION 2.0 - GENERAL DESCRIPTION

2.1 COLUMBIA RIVER DEVELOPMENT

The Columbia River system at the Murphy Creek Project site drains an area of 88 000 km^2 in southeastern British Columbia and northern Idaho and Montana. The Columbia River has its source in Columbia Lake, in the Rocky Mountain Trench, and from there flows northwest and then south for a total of approximately 700 km to the Murphy Creek Project site. The Kootenay River, the major tributary to the Columbia River above the Murphy Creek site, originates in the Rocky Mountains, and flows south, west and then north for a total of approximately 500 km into Kootenay Lake. From Kootenay Lake, the river flows southwest for 30 km to its confluence with the Columbia River at Castlegar.

Existing storage projects on the Columbia River system upstream of the Murphy Creek Project provide over 31.3 x $10^9 m^3$ of live storage. These comprise Mica Dam and Hugh Keenleyside Dam on the Columbia River, Libby Dam on the Kootenay River and Duncan Dam on the Duncan River, a tributary of Kootenay Lake. The outlet of Kootenay Lake is regulated by the Corra Linn Project. All other hydroelectric projects above the Murphy Creek site are run-of-river projects, with no significant live storage. The Revelstoke Project, presently under construction, will also be operated primarily as a run-of-river project.

Operation of 19.1 x $10^9 m^3$ of storage at Mica, Hugh Keenleyside and Duncan projects is governed by Assured Operating Plans (AOP) prepared each year in accordance with Annex A of the Columbia River Treaty.

2.2 AREA DESCRIPTION

The Columbia River flows east from the Hugh Keenleyside Dam for about 9 km, then at Castlegar turns south just upstream of the confluence of the Kootenay River. Downstream of Castlegar the Columbia River flows south to the proposed project site some 3 km upstream of Trail. The Columbia River continues downstream of Trail, crossing the United States border just below the confluence of the Pend d'Oreille River. The town of Castlegar and a number of small communities and rural settled areas are adjacent to the river (Fig. 1-1). The river valley is characterized topographically by a series of alluvial terraces. The valley sides are well defined and steep, with bedrock outcrop and some forested areas.

A major highway and the Canadian Pacific Railway cross the Columbia River in Castlegar. A highway and rail line parallels the river on the west bank between Castlegar and Trail. This transportation corridor would be the main access to the project site.

2.3 RESERVOIR LEVEL

In the feasibility studies for the Murphy Creek Project[1] project arrangements were developed for three reservoir levels, El. 424 m, El. 427 m and El. 430 m. A reservoir level of El. 424 m has been selected for further studies of the Murphy Creek development.[2] The lower (El. 424 m) reservoir level would limit the amount of flooded land and, combined with installation of power facilities at Keenleyside, would provide a power development close to optimum. With a reservoir level at El. 424 m, the Murphy Creek Project would raise the Columbia River approximately 15 m at the project site and approximately 4 m at the Hugh Keenleyside Dam; it would raise the Kootenay River approximately 3.1 m at the Brilliant Dam.

2.4 PROPOSED DEVELOPMENT

The Murphy Creek Project would have limited reservoir storage. The project would be designed and operated with average monthly outflows approximately equal to inflows as required to meet Columbia River Treaty requirements and load-factoring at the generating plant. The project would have a rated head of 13 m and an installed generating capacity of 300 MW. The proposed arrangement comprises an earth/rockfill dam with till core in the river channel. The powerhouse would be located on the right bank housing five vertical shaft Kaplan units and a five-bay spillway would be between the powerhouse and the dam.

The main project structures on the dam axis would be located, at their closest point, approximately 200 m from the community of Oasis and approximately 500 m from the community of Rivervale. The existing highway and railway located between Oasis and the project site would be relocated.

SECTION 3.0 - RESERVOIR OPERATION AND FLOWS

3.1 RESERVOIR OPERATION REGIMES

Two Arrow Lakes Reservoir operating regimes have been considered in studies of the Keenleyside-Murphy Project.

Operating Regime 1 is essentially the existing regime for the Arrow Lakes Reservoir in which use is made, in most years, of close to the maximum available live storage. This results in a fairly long period, generally mid-January to mid-June, when the Arrow Lakes Reservoir is partially evacuated. Whenever the Arrow Lake Reservoir is partially evacuated, the Murphy Creek Reservoir would also have to be lowered to allow the required discharge capability at Keenleyside to be met. For the balance of the year the Murphy Creek Reservoir would be maintained as near as possible to the normal operating level of El. 424 m, (subject to daily fluctuations required for operational purposes) as measured at the Castlegar Ferry water level gauge.

To maximize generation at Keenleyside and Murphy and to mitigate potential environmental impacts caused by reservoir drawdown, several alternative operating regimes for the Columbia River system with reduced Arrow Lakes drawdown have been investigated. One of these, termed Operating Regime 2, involves a reduction of the mean annual drawdown of the Arrow Lakes and an increase in the mean annual minimum reservoir level. Under this regime, the reservoir at Murphy would be generally at the normal operating level El. 424 m, subject to daily fluctuations required for operational purposes.

For most of the project life Regime 2 is expected to be much more representative of operation than Regime 1. For this reason Operating Regime 2 has been chosen as the basis for project design. When the

operating flexibility of the Columbia River Treaty projects improves following expiration of the Treaty, it is expected that the operating regime may be further refined to increase power generation, improve flood control at Trail or reduce the environmental impacts of reservoir drawdown.

3.2 FLOOD FLOWS

The Probable Maximum Flood (PMF) for the Murphy Creek Project was estimated using watershed modelling of the basin.[3] Runoff conditions resulting in the PMF peak flow would be produced by the joint occurrence of an extrememly high snowpack in early July, and a 20-day extreme warm temperature sequence (return period of 1000 years) starting 7 July. The weather sequence would be followed by the Probable Maximum Rain event at a time when the upstream reservoirs had been filled so they would have limited flood control capability to attenuate the peak runoff. Under these conditions, a PMF peak of 13 140 m^3/s would be produced on 2 August at the Murphy Creek Project.

A regulated flood frequency study derived estimates for spillway design and diversion during construction floods.[4] The Spillway Design Flood (SDF) was defined as the 200-year return period flood and would limit flooding at Castlegar. The term SDF has been used in a number of previous studies to describe the 200-year flood. The Diversion during Construction Flood was tentatively selected to have a return period of 30 years.

The results of these studies were:

200-year Flood	7 500 m^3/s
Diversion during Contruction Flood	6 200 m^3/s

The spillway would be designed to pass the 200-year flood, with the reservoir level at Castlegar approximately 0.2 m above the river level that would have occurred naturally for the same flood without the Murphy Creek Project. This level would be approximately 1.5 m above the normal operating level for the Murphy Creek Project. There would be no damage to the spillway.

The spillway would also be designed to pass the Probable Maximum Flood with the reservoir level at Castlegar approximately 0.7 m above the regulated PMF river level that would have occurred naturally without the Murphy Creek Project. There might be some limited damage to the spillway and other structures under this extreme flow condition.

SECTION 5.0 - RESERVOIR

5.1 RESERVOIR BANK STABILITY

The riverbank between the proposed damsite and Hugh Keenleyside Dam has been investigated and the soil conditions and bank stability evaluated.

The riverbank consists of fine grained silt and granular materials including sand, gravel and cobbles and in some areas these materials stand relatively steeply (1 vertical to 1.2 horizontal) and are likely to be unstable and subject to ravelling. As these banks erode they develop beach slopes near the present river level. Coarse gravel, cobbles and boulders pave the existing beach slopes.

The riverbank has been studied to assess reservoir shoreline regression.[5] Terrain analyses indicate that the main cause of any shoreline regression following filling of the reservoir would be beaching and ravelling due to wave action, rather than any "deep-seated" sliding. Based on this conclusion, shoreline regression has been estimated using long-term (75 to 100-year period) beach slopes for the various materials along the proposed reservoir shoreline. The beach slopes were determined using information obtained from an Arrow Lakes Reservoir study. A study of wind duration at various reservoir elevations indicated that most beach erosion would occur with the reservoir at the normal operating level (El. 424 m).

In areas where riverbanks are steep, the reservoir shoreline study concluded that formation of beach slopes would be accompanied by regression of the banks behind the beach until a stable condition was reached. The amount of regression of very steep banks behind the beach was based on developing a generalized stable slope assumed to be

1 vertical to 1.5 horizontal. Based on this postulated mode of regression, a preliminary safeline was developed.

5.2 SHORELINE PROTECTION WORKS

The shoreline has also been studied to determine which portions could be protected from inundation and/or erosion. In most areas where the preliminary safeline would otherwise encompass residences, commercial buildings, rail lines, roads, sewage lagoons and cemeteries, shoreline protection works would be built. These protective works would contain the impact of the reservoir and a reservoir impact line was developed to identify the limits of impacts where protective works are proposed. Shoreline protection works would be provided before reservoir filling in all cases except for roads which would be protected after reservoir filling if significant erosion occurred. The protection works would be rock and/or granular fill toe protection along portions of the river banks as part of project design.

The proposed location of reservoir shoreline toe protection works has been evaluated initially by comparing preliminary costs of the protection works to the estimated value of property. However, provided the value of developed property is reasonably close to the estimated cost of toe protection the preference would be to avoid relocation of an existing residence.

Protective berms and fill in certain low-lying and shallow sloping areas are being considered as a mitigation opportunity.

5.3 INFRASTRUCTURE

Construction of the proposed dam and impoundment of the reservoir would affect to a limited extent the following infrastructure:

Municipal services, including water supply and sewage storm drains and roads (not highway).

Utilities including gas pipelines, telephone lines and electric power lines, both crossing the river and on the shoreline.

Highways, including bridges.

CP Rail line, including bridge.

B.C. Timber Pulpmill and Sawmill.

(a) Municipal Infrastructure

A summary of municipal infrastructure that would be affected together with proposed remedial works is as follows;

Location	Infrastructure	Proposed Remedial Works
East Raspberry	Road Sewerage	Raise Modifications to sewage lagoon effluent works
Ootischenia	Road/Berm	Raise
North Castlegar	Roads Sewerage Drainage	Raise Pump stations relocated Replace
South Castlegar	Roads Waterworks Sewerage	Raise Raise well and main Add diffuser, relocate pump stations
Genelle	Roads Waterworks Sewerage	Raise Reconstruct Reconstruct

(b) Utilities

Utilities affected by the reservoir would be as follows:

WKPL transmission lines (main and distribution)
B.C. Tel telephone/cable lines
CP Telecommunications cable lines
Inland Natural Gas; pipeline

In the project area, utilities cross the reservoir and are located along the shorelines. For reservoir crossings and along the shoreline, all crossings that would be impacted would be relocated and constructed to conform to regulatory clearance requirements and to ensure all towers/poles and structures are located beyond the reservoir impact lines. There are a total of 14 utility crossings of the reservoir, of which 12 would be impacted.

The reservoir would inundate a portion of the WKPL transmission lines as it runs along the shoreline at Waterloo Eddy, just downstream of Ootischenia. The area around the inundated poles would be filled and protected from erosion.

The buried Inland Natural Gas pipeline in North Castlegar would be submerged in certain areas. The buried pipeline would be protected, weighted to counteract buoyency, valves and controls raised.

Construction at the Murphy Creek project site would affect the WKPL transmission lines. The line would be temporarily relocated during relocation of the highway and rail line. Following this construction the transmission line would be returned essentially to its original corridor but with location of poles and spans adjusted to tie in with the highway and rail line.

(c) Highways

Excavation for the Murphy Creek structures would impact Highway No. 22 between Trail and Castlegar. The highway would be relocated between the relocated CP Rail line and Oasis.

A limited amount of protective works would be required for the abutments of the highway bridge in Castlegar.

The highway between Robson and the Keenleyside Dam would be partially affected along portions of its length. The toe of the highway embankment slope would be protected if required. The slope would be monitored regularly and protection would be placed as required. The area is easily accessible for placing protection materials from the road.

The gravel public road between Ootischenia and Champion Creek would be inundated by the reservoir for approximately 1.2 km. The road would be raised to above the reservoir impact line and protected where necessary.

(d) CP Rail

The excavation for the Murphy Creek structures would impact on the CP Rail line. The railway would be relocated between the excavation limits and the relocated highway.

Impoundment of the reservoir would impact approximately 5.4 km of track between Birchbank and the project site. The track would be raised while maintaining service, and the Murphy Creek crossing and the Birchbank siding would be rebuilt.

Upstream of Birchbank there are seven areas where the reservoir would impact the CPR line. In these areas toe protective works

would be placed at the base of the slopes. In addition protective works would be required for the relocated track between Birchbank and the project site. The CP Rail bridge crossing abutments in North Castlegar would be protected.

(e) B.C. Timber

There would be a limited impact from the reservoir on the B.C. Timber Pulp and Sawmill. This would be mainly limited to the riverbank protection works which would require upgrading and extending.

(f) Cemeteries

Two cemeteries could be potentially impacted by reservoir beaching action. The "safeline without protection" would encroach on a portion of cemeteries at Brilliant and Champion Creek.

To avoid this potential impact, the reservoir slope under the cemeteries would be protected.

5.4 AREA AND VOLUME

The area of the reservoir at the normal operating level, El. 424, would be about 1300 ha. The volume of the reservoir at the normal operating level, El. 424 m, would be about 140 x $10^6 m^3$.

The reservoir would extent to Hugh Keenleyside Dam on the Columbia River and Brilliant Dam on the Kootenay River. The total flooded area would be approximately 302 ha, measured between the average annual high water level under existing conditions and the normal operating reservoir level.

SECTION 6.0 - CONSTRUCTION

6.1 CONSTRUCTION SCHEDULE

The construction schedule is based on an in-service date of 1993. The schedule has a construction period of 5 3/4 years from issue of the tenders for the turbine and generator contracts in the spring of 1988 to bringing the first unit in service by July 1993. It may be necessary to issue tenders for road, rail and powerline relocation work around the powerhouse area up to 1 year earlier than the 1988 start. Additional units would come on line at intervals of 4 months. Diversion through the spillway would commence 3 1/2 years after award of the first contract.

6.2 SEQUENCE OF CONSTRUCTION

Following relocation of the highway, railway and powerlines around the project structures, construction would begin in the spring of 1988 under the first civil contract for development of site access, camps and work areas (Phase A). Initial excavation for the approach and tailrace channels would start in the summer of 1988 and continue through the spring of 1989. Construction of the cellular cofferdam would start in the spring of 1989.

The second civil contract would be awarded in the summer of 1989 with excavation for the powerhouse and spillway (Phase B). Excavation on the left bank for the concrete diaphragm wall would commence in the fall of 1989 with construction of the wall starting in the spring of 1991. Concrete placement for the powerhouse and spillway structures would start in the spring of 1990 (Phase C). Excavation for the approach and

tailrace channels would be completed and the spillway ready for diversion in late fall 1991.

Prior to diversion an earth/rockfill cofferdam would be constructed around the uncompleted powerhouse or rock plugs left in place. For diversion, channel rock plugs and part of the cellular cofferdam would be removed. Rockfill dykes would be constructed in the river channel and the cellular cofferdam removal would be completed after diversion (Phase D). The embankment dam would be constructed during 1992 and the diaphragm wall under the dam constructed with the fill partially completed. Installation of the turbines would start in the fall of 1991 with the first two units in service by October 1993 (Phase E).

Placement of reservoir bank protection, and berms and fill in low-lying areas would start in 1991 and be completed prior to reservoir filling. The railway line upstream of the site would be raised and all infrastructure that would require raising or relocation would be completed prior to reservoir filling in spring 1993.

6.3 CONSTRUCTION METHODS AND PLANT

Methods and equipment employed for construction of the project would generally be the Contractor's choice. However, construction practices would be controlled to ensure a minimum impact on the surrounding environment and equipment would be required to meet specific noise limiting criteria. For planning purposes, the following assumptions have been made as to the construction methods.

The main activities for the first civil contractor would be excavation of overburden and rock for the approach and tailrace channels by drilling and blasting, and loading and hauling to spoil areas, development of the site, the construction of the cellular cofferdams and widening of the river channel in the wet.

The main activities of the second civil contractor would be excavation, concrete placing and fill placing. The overburden and rock excavation for the powerhouse, spillway and channels would be completed as well as the overburden excavation for the concrete diaphragm wall. Approximately 3 x $10^6 m^3$ of rock and 2 x $10^6 m^3$ of overburden would be excavated. Spoil areas would include the right bank of the river upstream of the project and Billy Creek. Approximately 360 000 m^3 of concrete would be batched and placed mainly in the powerhouse and spillway. Channel rock plugs and part of the cellular cofferdam would be removed in the wet and the rockfill dykes constructed in the river channel. Approximately 180 000 m^3 of rockfill and 70 000 m^3 of earthfill would be placed for construction of the embankment dam and dykes. The powerhouse cofferdam or rock plugs would be removed partially in the wet prior to reservoir filling.

The concrete diaphragm wall would be constructed using specialized equipment and methods suitable for walls of this depth and in this material.

Materials for the impervious core of the earthfill dam would be obtained from till deposits along the left bank of Murphy Creek approximately 4 km from its confluence with the Columbia River. The volume of impervious fill material required would be about 22 000 m^3 and the haul distance would be about 9.5 km.

Materials for concrete aggregate, granular fill, transitions and drains would be excavated from the left bank of the river close to the axis of the structures. Materials from the excavation for the left abutment concrete diaphragm wall may be utilized is suitable. The volume of processed granular material required would be approximately 540 000 m^3.

Materials for rockfill and riprap for the dam and dykes would be obtained from the rock excavation operations. Materials for reservoir

shoreline protection works would be obtained from rock excavation operations or oversize material from granular borrow pits.

6.4 CONSTRUCTION CAMP

The offices and single labour camp would be located on the right bank of the river downstream of the project structures and just upstream of Hanna Creek. This location would provide good access to all work areas. The single labour camp would accommodate up to 600 persons at the peak of construction. The proposed camp would comprise 8 two-storey 80-man bunkhouses, dining and kitchen facilities for 800 men, recreational hall, and parking stalls for 325 vehicles.

Offices for B.C. Hydro would be provided adjacent to the camp with parking stalls for 30 vehicles. Full services would be provided for the complex including water, sewage, electricity, gas, and telephone. Basic plans require that water be obtained from the Columbia River and treated before use, and sewage be treated in a package plant and effluent discharged into the Columbia River, subject to provinical pollution control standards. Other water and sewage alternatives are under review. Electric power would be obtained from West Kootenay Power and Light.

6.5 RIVER DIVERSION

Initial construction work would involve rock excavation for the approach and tailrace channels on the right bank of the river. During this phase of the work no diversion is required.

First stage diversion would direct the Columbia River to the left bank of the existing river channel by a cellular cofferdam. The cellular cofferdam would be about 240 m long and each cell would be 15.5 m in

diameter, requiring 15 cells, and up to 26 m in height. It would be necessary to widen the river channel by excavating and protecting the left bank to maintain acceptable water levels during diversion. Powerhouse and channel excavations would be protected by upstream and downstream rock plugs.

Second stage diversion would comprise two rockfill dykes in the existing river channel diverting flow through the completed spillway. Upstream and downstream channel rock plugs and the cellular cofferdam would be removed. An earth/rockfill cofferdam would be constructed around the uncompleted powerhouse or rock plugs left in place.

SECTION 7.0 - PROJECT OPERATION

7.1 RESERVOIR OPERATION

Over the life of the Murphy Creek Project, operation of the Arrow Lakes Reservoir would vary from the existing conditions, approximated by Regime 1, to future conditions approximated by Regime 2. The operation of the Columbia River system will gain additional flexibility when the Columbia River Treaty expires (2024), and at that time it may be possible to further refine the operating regime to improve power generation and flood control or reduce environmental impacts of reservoir drawdown.

The project design has been based on Operating Regime 2. As there is no certainty that this regime would be in effect immediately following completion of the project, it has been assumed that there would be a period with the project operating under Regime 1.

7.2 RESERVOIR FLUCTUATIONS

Daily fluctuations of reservoir water level at the dam for generation of electrical energy would be limited to 2.0 m during March and April of each year and 1.5 m in other months. Daily fluctuations upstream of the dam would be slightly less than the fluctuation at the dam, depending on location and inflow.

7.3 DOWNSTREAM CONDITIONS

The minimum flow downstream of the project would be maintained at 425 m^3/s under normal operating condition. However, Columbia River

flows less than 425 m^3/s could be requested by the U.S. to meet Columbia River Treaty requirements.

In the event of a complete plant load rejection, the spillway gates would open automatically to reinstate flow. Consequently, there would be only a minor effect on downstream flows and water levels.

Daily fluctuations of tailwater level at the dam for operational purposes would be limited to 3.0 m, with an hourly variation limited to 1.0 m.

PART II - PROJECT IMPACTS
SECTION 8.0 - INTRODUCTION

This part of the report contains project summary information on two sets of reports: environmental and socio-economic impact studies; and engineering impact studies.

Sections 8.1 through 8.3 expand on the approaches taken in the environmental and socio-economic studies, Section 8.4 outlines the engineering topics which were studied.

Sections 9.0 and 10.0 identify the study team and outline study requirements. Sections 11.0 to 23.0 provide summaries of environmental and socio-economic impact studies, and Sections 24.0 to 28.0 provide summaries of engineering impact studies.

8.1 DEVELOPMENT OF TERMS OF REFERENCE

The April 1980 terms of reference for detailed environmental and socio-economic studies prepared by B.C. Hydro (1980) underwent a review by local, regional and provincial government agencies prior to finalization. This document outlines the objectives of the studies which were to provide:

1. An inventory of study area resources that could be impacted by the potential project.

2. A comprehensive evaluation of project impacts, both adverse and beneficial, upon the existing resource base.

3. Sufficient information to develop mitigation and compensation proposals.

4. An evaluation of resource losses and gains in monetary terms for inclusion in a benefit-cost analysis and to serve as a base for mitigation and compensation planning.

As a result of the detailed environmental studies, a number of follow-up investigations were recommended and completed. Environmental studies initially focused on the potential project impacts for alternative normal headpond operating levels of El. 424 m, El. 427 m and El. 430 m. However, since late 1981, studies have focused on the impacts of the El. 424 m reservoir level along with development of the Keenleyside Powerplant Project.

8.2 STUDY AREA

The study area consisted of lands up to an elevation of El. 500 m on either side of the Columbia River from the axis of the proposed dam in the vicinity of Oasis, upstream to the Hugh Keenleyside dam on the Columbia River and to the Brilliant dam on the Kootenay River. Studies which were extended beyond this area in specific cases where considered necessary to properly evaluate potential impacts included:

1. Socio-economic - The study area was defined as School District No. 9, centered on Castlegar, and School District No. 11, centered on Trail and Rossland. Since the effects of development often influence socio-economic conditions outside the immediate environs, efforts were also directed to an examination of a study region defined as the Regional District of Kootenay Boundary plus the Regional District of Central Kootenay.

2. Wildlife - In the vicinity of proposed borrow areas, where construction activity would approach the El. 500 m contour elevation, field data collections were extended. Required field data

was also collected on lower Arrow Lake and the Brilliant Dam reservoir for comparative purposes.

3. Fisheries - Sampling and tagging operations were extended to include the section of the Columbia River between the proposed dam and the International Boundary.

4. Downstream Water Use - The primary study area was considered to be from the proposed damsite to the International Boundary. To assess waste systems, the study area was expanded to encompass Genelle-China Creek and the communities in the Castlegar area.

5. Vegetation - The basic study area was expanded to the 800 m contour from the City of Trail to the Brilliant Dam, the Hugh Keenleyside Dam and 8 km up Pass Creek.

6. Recreation - As noted for socio-economic studies.

8.3 DISCIPLINES

The terms of reference which have previously been made available to the public provide guidelines on the level of effort, inventory, planning and assessment requirements for 14 study disciplines, namely;

Geology and Land Forms
Water Quality
Agriculture
Forestry
Fish and Aquatic Habitats
Recreation and Tourism
Land Use
Hydrology and River Morphology
Climate
Vegetation
Wildlife
Socio-economics
Heritage Resources
Downstream Water Use

8.4 ENGINEERING STUDIES

In addition to the Environmental and Socio-economic studies, impact assessments were undertaken on the following topics:

- Camp
- Groundwater
- Noise, Vibration and Dust
- Reservoir Shoreline and Protective Work
- Infrastructure

The terms of reference for these studies have also been previously made available to the general public.

SECTION 9.0 - STUDY TEAM

9.1 CO-ORDINATION

B.C. Hydro provided general direction for the entire study. This involved: drafting of terms of reference; maintaining study schedules and budgets; ensuring continuous information exchange among participants; monitoring progress; developing the assessment format; co-ordinating environmental input to project planning; and preparing a final summary report.

9.2 SPECIALIST CONSULTANTS

Specialist consultants (Table 9-1) were retained by B.C. Hydro to conduct discipline studies and provide planning input in their areas of expertise. Each of these consultants has prepared a discipline-oriented report on the Murphy Creek Project. These reports were used as the basis for this summary and are listed in Bibliography.

TABLE 9-1

MURPHY CREEK PROJECT
STUDY RESPONSIBILITIES

Discipline	Responsibility
Co-ordination	Monenco Consultants Pacific Ltd./ B.C. Hydro, Environmental and Socio-economic Services/B.C. Hydro, Hydroelectric Generation Projects Division
Hydrology, River Morphology and Climate	B.C. Hydro, Hydroelectric Generation Projects Division
Geology and Landforms	B.C. Hydro, Hydroelectric Generation Projects Division
Vegetation	Talisman Land Resource Consultants
Forestry	Talisman Land Resource Consultants
Wildlife Resources	Beak Consultants Limited
Aquatic Resources	R.L.&L. Environmental Services Ltd.
Water Quality	International Environmental Consultants Ltd.
Downstream Water Use	Kerr, Wood, Leidal and Associates Ltd.
Land Use	Urban Systems Ltd.
Agriculture	Talisman Land Resource Consultants
Recreation and Tourism	Edwin Reid and Associates Ltd.
Socio-economics	D.P.A. Consulting Limited
Heritage Resources	Okanagan College
Angler Survey	B.C. Fish and Wildlife Branch
Camp	Bowman Engineering Associates Ltd.
Groundwater	Pacific Hydrology Consultants Ltd.
Noise, Vibration and Dust	Hartford, Kennedy, Wakefield Ltd./ B.C. Hydro, Hydroelectric Generation Projects Division
Reservoir Shoreline and Protective Work	Thurber Consultants Ltd./B.C. Hydro, Hydroelectric Generation Projects Division
Infrastructure	Dayton and Knight Ltd., Thurber Consultants Ltd., Stothert [illegible]oup

SECTION 10.0 - STUDY REQUIREMENTS

The terms of reference give the following guidance as to the direction and scope required in developing specific methodologies to assess the impact of the potential project. Project methodologies were to take account of:

1. all resources and their significance, with and without the project, on a local, regional and provincial scale based upon present value and potential value;

2. environmental and socio-economic impacts including:

   a. primary, secondary and induced impacts.

   b. beneficial and adverse effects.

3. distributional aspects of impacts including:

   a. geographical - local, regional and provincial.

   b. social - impacts on various segments of the population, ethnic or special interest groups.

   c. transfer of resource demands to other locations.

4. probability of occurrence of an impact and reasons for uncertainty of the impact's occurrence;

5. expected time and duration of an impact occurrence. A distinction shall be made between short-term impacts (those which last for the

construction period only) and long-term impacts (those which persist after construction);

6. possible benefits, both short and long-term, of all compensation and mitigation measures;

7. the costs associated with all compensation and mitigation measures;

8. relationship between project impacts and long-term regional development prospects.

In order to promote an exchange of information amongst specialist consultants and engineering teams, to consider overlapping data bases and impacts, and to facilitate environmental input to the project planning process, monthly co-ordination meetings were held in B.C. Hydro offices. All consultants were encouraged to meet with agencies and groups within the study area to ensure that local feedback was entered into the assessment of the project. B.C. Hydro's planning and community relations programs provided review and feedback on study priorities from in-house staff, government representatives, consultants and the public.

SECTION 11.0 - HYDROLOGY, RIVER MORPHOLOGY AND CLIMATE

11.1 INTRODUCTION

Section 11.0 examines the potential project impacts on hydrology, river morphology and climate.

11.2 PROJECT IMPACTS

(a) Streamflows

The Murphy Creek Project would be operated as a run-of-the-river project in accordance with the Columbia River Treaty. Due to the small volume of the Murphy Creek reservoir, it would affect the daily reservoir outflow for only a few days in most years while the reservoir is filling or emptying. Flow velocities within the reservoir would be significantly less than under existing conditions. Average velocities upstream of the damsite at normal operating level would be reduced to approximately 60 percent of natural channel velocities during periods of high flow and reduced to approximately 20 percent during periods of low flow. These reductions in flow velocities would be less at Castlegar than at the damsite.

(b) Water Levels

Under reservoir Operating Regime 1, in an average year, the level of the Murphy Creek Reservoir would drop to El. 418 m during the February-April period to facilitate evacuation of stored water in Arrow Lakes Reservoir. Except for daily operational variations, the reservoir would be at the normal operating level between June

and January of the following year. The minimum stage for a 35-year simulation of Regime 1 was El. 413.3 m. Maximum spring reservoir levels would occur in years when it would not be necessary to draw down Arrow Lakes Reservoir below the normal operating level of Murphy Creek Project.

Under reservoir Operating Regime 2, the Murphy Creek Reservoir would rarely (about once in 35-years) be drawn down below its normal operating level, except for daily operational requirements. Under this Regime it would normally not be necessary to draw down the Arrow Lakes Reservoir below the Murphy Creek Reservoir normal operating level.

Under both regimes, daily fluctuations of reservoir water level at the dam for operational needs would be limited to 2.0 m during March and April of each year and 1.5 m in other months.

Annual maximum water levels would be raised an average of 15 m at the Murphy Creek Project site and 4 m at Castlegar Ferry compared to the present conditions without the project. During periods of extremely severe flooding, the levels would be exceeded (by 1.5 m at Castlegar) for a few days. However, this is only nominally above the water level that would occur for the same flood without the Murphy Project.

(c) Sediment Regime and River Morphology

Very little change in the river channel morphology would be expected to result from the Murphy Creek Project.

Suspended sediments entering the Murphy Creek Reservoir from the sources upstream of the Hugh Keenleyside and Brilliant dams would not accumulate, but would be carried on through by reservoir current. Reduced velocities in the Columbia River after completion

of the Murphy Creek Project would result in a low, but measurable buildup of sediment at the deltas of Norns, Blueberry, China, Champion and Murphy creeks.

(d) River Temperature

During winter months, the temperature losses in the Columbia River between Castlegar and the proposed Murphy Creek damsite is estimated to be about 0.4°C, somewhat less than the maximum 1.5°C temperature loss under pre-1968 conditions. Ice cover formation would not be an important consideration for this project.

(e) Climate

Micro-climatic changes in temperature, precipitation form, wind and fog occurrence, due to the formation of the Murphy Creek Reservoir, would be very minor and would be confined to the reservoir and its immediate shoreline. These changes would not affect overall meteorological conditions in the project area.

Spillway operations at the dam would produce an increase in the frequency of fog only in the immediate vicinity (within 50 to 60 m) of the project. During the winter months, there may be some ice-accretion on facilities at the dam.

11.3 MITIGATION OPPORTUNITIES

The potential hydrological, morphological and climatic impacts of the Murphy Creek Project are expected to be minor. Nevertheless, in order to evaluate a need for specific mitigation measures, it is recommended that:

1. Sediment accumulation near the mouths of major creeks be monitored during operation of the proposed Murphy Creek reservoir.

2. The Atmospheric Environment Service be asked to install a climatological station and anemometer on the Murphy Creek Dam so that any localized micro-climatic effects of the project may be measured.

SECTION 12.0 - GEOLOGY AND LANDFORMS

12.1 INTRODUCTION

Section 12.0 describes potential project impacts on geology and landform in the study area.

12.2 PROJECT IMPACTS

Most of the proposed reservoir banks consist of various gravel and sand with small amounts of silt. The slope of the immediate riverbanks are generally steep and show signs of sloughing due to river undercutting and erosion by water. By raising the water level, the river downcutting effects would be reduced, but in some places beaching would be increased.

Bedrock in the area consists mainly of metasedimentary and igneous rocks ranging in age from Paleozoic to Tertiary. There are no known mineral occurrences in the reservoir, but there are uranium showings within the study area. Mineral claims extend over the Columbia River valley and several are within the proposed Murphy Creek Reservoir. There are no coal deposits in the reservoir area and no potential for oil or gas exists. A potential 7 million cubic metres of aggregate are found in the reservoir area. This represents about 4 percent of the total aggregate potential ($168 \times 10^6 m^3$) in the study area.

No landforms which would have special interest because of their type, number, size or state of preservation were found in the study area.

12.3 MITIGATION OPPORTUNITIES

Prior to the definition of any specific mitigation measures, it is recommended that a thorough evaluation and establishment of ownership be made for all gravel borrow areas in the flooded area, mineral claims and potential mineral claims, and that the reservoir banks be evaluated for stability and required protective works.

SECTION 13.0 - VEGETATION

13.1 INTRODUCTION

This section summarizes impacts on vegetation within the Castlegar/Trail study area and the West Kootenay region.

13.2 REGIONAL IMPACTS

Deciduous forests, mixed wood forests and shrub communities which occur on the banks and lowlands along or near the Columbia River would be most affected by the proposed Murphy Creek development. There would be no single vegetation type totally eliminated from the study area. In most cases inundation would affect the lower portions. The only plant species that would be substantially affected by the project appears to be Rocky Mountain Juniper, which is found in the study area in scattered locations along the banks of the Columbia River. Most juniper trees are found below the normal reservoir operation level. However, this species is found sporadically in upland areas not subject to flooding. In a broad regional context, juniper is not considered to be a rare or unusual species.

There would not be any major (regional) loss of coniferous forest stands.

In a regional sense, the loss of lowland vegetation, however limited, is considered significant. This is particularly true in the Castlegar/ Trail area where nearby impoundments have already removed hundreds of hectares of productive lowland vegetation. However, because the Murphy Creek reservoir will have a relatively low head and because the reservoir area is already highly developed and disturbed by man, the impacts

of the project from a vegetation perspective are not considered to be a major environmental concern.

13.3 LOCAL IMPACTS

Impacts on vegetation are classed as either direct or indirect. Most direct impacts (Tables 13-1 and 13-2) are losses of vegetation due to clearing, inundation or other complete alteration of the supporting soils such that the original vegetation type will not recover following the disturbance. Other direct impacts may not be permanent and include vegetation losses due to cutbanks, borrow operations, temporary access roads and temporary construction camps. Indirect impacts are secondary effects such as bank erosion or slumping which could be attributed to the project. These latter impacts can also be largely considered as temporary and their severity related to length of time required for the vegetation recover.

Approximately 217 ha of lowland vegetation would require clearing at reservoir El. 424 m (Table 13-1). Approximately 71 ha (Table 13-2) of natural vegetation would be occupied by activities associated with dam construction.

Direct and indirect effects on vegetation are expected to be most widespread and significant at the lowest portions of the alluvial fans, and at the confluences of creeks which flow into the Columbia River. Impacts on vegetation are expected to be highest at the following locations: Pass Creek valley and alluvial fan; Kootenay River and Selkirk College lowlands; Champion Creek valley and alluvial fan; Blueberry Creek/China Creek valleys and fans; and Jordan Creek to Billy Creek lowlands.

None of the potentially impacted areas of vegetation is in an ecological reserve or in an area for which application for reserve status has been made or is pending.

13.4 MITIGATION OPPORTUNITIES

Measures to reduce or mitigate potential impacts on vegetation are limited because most of the impacts on the vegetation base are considered permanent. The following recommendations may reduce impacts by aiding stabilization of the soil and protection of lowland sites, and reducing the time requirements to re-establish a self-sustaining vegetative cover.

1. Clearing around the reservoir area should be confined within the zone of inundation as much as possible. Existing access roads should be utilized wherever possible.

2. A reclamation plan should be prepared prior to any clearing program and should be initiated for any area of major disturbance. Site preparation, resloping and re-vegetation should be completed as soon as possible after the disturbance has taken place.

3. Slash and debris should be removed from the reservoir area.

TABLE 13-1

SUMMARY OF DIRECT VEGETATION IMPACTS

	Sub-Area	Area*1 (ha)
1	Columbia River North Shore	4
2	Columbia River South Shore	4
3	Pass Creek	24
4	Kootenay River	6
5	Castlegar-Kinnaird	31
6	Castlegar Airport	13
7	Champion and Jordan Creeks	19
8	Blueberry Creek-Genelle	29
9	Billy Creek	37
10	Oasis	50
	SUB-TOTAL	217
	CUMULATIVE TOTAL	217

*1 Does not include non-vegetated areas, or areas of disclimax plant communities developed after continuous disturbance.

TABLE 13-2

SUMMARY OF DIRECT VEGETATION IMPACTS
RELATED TO DAMSITE CONSTRUCTION

	Sub-Area	Area (ha) of Vegetation*1 Occupied by Works*2
9	Billy Creek	50
10	Oasis	21
	TOTAL	71

*1 Does not include non-vegetated areas, or areas of disclimax plant communities developed after continuous disturbance.

*2 Includes cut and fill areas along proposed dam axis, spill-way and powerhouse works, and relocation of highway, railway and transmission line rights-of-way required for dam con-struction. Possible access roads and a possible transmission line right-of-way to carry Murphy Creek power have not been assessed due to lack of definition.

SECTION 14.0 - FORESTRY

14.1 INTRODUCTION

This section provides an analysis of the potential impact on forestry resources due to the Murphy Creek Project, together with a description of the consultant's recommended mitigation opportunities.

14.2 REGIONAL IMPACTS

The total allowable annual cut from Crown lands within the study region is 274 670 m^3. The contribution of lands from the study area to this regional supply is negligible. The maximum 900 m^3/year of potential timber production that could occur if all potentially affected areas at reservoir elevation El. 424 m were managed for timber production, would represent less than 1 percent of the regional cut. The maximum potential timber production of 60 m^3 that would be lost from only those affected areas currently under forest cover, represents an even smaller percentage of the regional cut, although it may be significant to some small logging operations and mills, given the projected timber deficit for the region.

14.3 LOCAL IMPACTS

(a) Forest Cover and Capability

Only a few areas of forest cover have potentially merchantable stands. The only location within the study area which could offer a reasonable logging opportunity (and only if markets are accessible) is a 1 ha stand of cottonwood in the Pass Creek area. A summary of forestry cover inundated is presented in Table 14-1.

Land areas that would be inundated by BCLI Forest Capability Class, are summarized in Table 14-2. A total of 301 ha would be inundated at the El. 424 m reservoir level. Only a small part of the area inundated is presently occupied by forest cover and most of these stands are not adequately stocked with commercial trees. It would be misleading to assess impact on the basis of forest capability only since none of the lands appear to be managed for timber production, and existing land ownership patterns dictate against the forest resource potential ever being realized. Although the potential for timber production exists for much of the area potentially inundated, it is not being used at present and does not appear that this will change in the absence of the project.

Within the potential project borrow areas, short-term impacts of road construction is expected to range from low to high. Long-term forest losses due to clearing in the Murphy Creek area are considered to be high as this area has a greater extent of forested land and better quality growing sites than other till deposits in the region. The removal of some of the better quality immature stands from the forest land base may have some impact on local timber supply, since the estimated annual yield losses from the development of the till site could make up one-third to one-half of small operators' annual wood requirements. Given that timber supply is considered to be "tight" in the area, the impact becomes significant. However, the estimated annual yield of the Murphy Creek borrow area makes up less than 1 percent of the present total allowable annual cut for the region.

(b) Forestry Values

If all potentially affected lands within the study area were managed for timber production, an estimated 900 m^3/year of potential timber production would be lost at the El. 424 m reservoir level. The maximum future production potential from all capable

lands inundated at the proposed reservoir level is estimated to be $45,000 (present value). For this to occur would require that all inundated lands be restored and managed as commercial forest wherever applicable; this scenario is not projected to occur.

If the production potential of all lands with mature or immature forest cover in the study area are evaluated, an estimated 60 m^3/year of potential timber production would be lost at the El. 424 m reservoir level respectively. This production potential has a present value of $3000.

Since most lands in the study area are not in fact presently managed for timber production, and are not expected to be available for timber production in the future, there should be no impact from the project on the study area's forestry potential.

The loss of a few stands which might provide minor forest products (cordwood, fence posts and rails) may be locally important to some individuals.

14.4 MITIGATION OPPORTUNITIES

As discussed in the foregoing sections, most of the stands in all of the reservoir areas examined do not appear to offer a reasonable logging chance because of their scattered occurrence, small extent, low merchantable volumes per hectare, and generally low log quality. Commercial logging of the reservoir area does not appear to be an appropriate mitigation measure.

Selling or giving away firewood to local residents could be considered. Firewood could be cut from some of the few mixed stands of white birch, lodgepole pine, western larch and Douglas fir which are scattered

throughout the reservoir areas. A rough estimate of available firewood which could be cut is 100 cords at the El. 424 m reservoir level.

TABLE 14-1

SUMMARY OF FOREST COVER INUNDATED

	Sub-Area	Volume*1 (m^3)	Area (ha)
1	Columbia River North	10	0.20
2	Columbia River South	6	0.04
3	Pass Creek	200	1.00
4	Kootenay River	-	-
5	Castlegar-Kinnaird	-	-
6	Castlegar Airport	-	-
7	Champion and Jordan Creeks	490	4.40
8	Blueberry Creek-Genelle	-	-
9	Billy Creek	40	7.20
10	Oasis	-	-
	CUMULATIVE TOTAL	746	14.60

*1 Volume estimates are net volumes at close utilization standards, less decay.

TABLE 14-2

STUDY AREA SUMMARY
AREAS OF FOREST CAPABILITY TYPES INUNDATED

BCLI Forest Capability Class	Area (ha)
1	-
2	-
3	37.0
4	182.0
5	2.0
6	33.0
7	47.0
TOTAL	301.0

SECTION 15.0 - WILDLIFE

15.1 INTRODUCTION

This section summarizes the potential impacts of the Murphy Creek Project on wildlife resources within the Castlegar/Trail study area.

15.2 PROJECT IMPACTS

(a) Ungulates

The Murphy Creek Project is expected to have only moderate to insignificant impacts on the ungulate populations or habitat within the study area. The principal areas of wildlife habitat which would be flooded are restricted to lower Pass Creek and Champion Creek. The remainder of the flooded area would be primarily steep slopes which have little value as wildlife habitat, or areas which have already been alienated by residential, linear, industrial or agricultural development. The removal of winter habitat for deer would be a direct long-term effect, but because of the small amount of land involved, would represent only a moderate impact for local populations. Construction activities would result in a disturbance of wildlife habitats over the long term at borrow and spoil areas. Reclamation would reduce these effects to short-term impacts.

Reservoir flooding would result in a lost carrying capacity for deer through the elimination of the following habitat: 8 ha of moderate/high class land, 37 ha of low/moderate class land, 348 ha of low class land, and 6 ha of altered land. This would result in an estimated loss of capability during a severe winter for 9 to 22 deer.

No adverse effects to the elk population are foreseen as a result of the development.

(b) Aquatic Furbearers

The effect of fluctuating water levels upon aquatic furbearers is expected to be moderate, but owing to the small population at present, the impact upon trapping would be minor.

(c) Birds

(i) Aquatic Birds

Impacts on ducks and geese within the study area would be moderate, long term and negative, but involve small numbers in a regional context. Principal impacts would occur as a result of fluctuating reservoir levels which limit successful breeding and inhibit the development of submergent aquatic vegetation and associated fauna.

Given the preference of mergansers for flowing water and their distinctive life history, particularly as fish eaters, the project would result in a 60 to 75 percent reduction of their population. This would constitute a moderate long-term negative impact to a population whose numbers in a regional context are likely to be much greater than dabbling and diving ducks.

Spotted sandpiper, common along the banks of the Columbia River, appear to prefer the rocky shorelines of rivers and creeks. Flooding of the reservoir would eliminate this habitat and fluctuation of a reservoir would likely prevent re-establishment of suitable habitat. This impact is considered moderate and long term.

(ii) Terrestrial Birds

Impacts on osprey within the study area would result from the loss of 1 or 2 nest sites. The impact on kestrels would be short term depending upon the time required to re-establish cottonwoods at the new reservoir level.

(iii) Upland Game

Although some habitat in the Champion Creek area and the Genelle to Blueberry area would be lost, surveys and discussion with local individuals indicate that the main ruffed grouse concentration centres above the reservoir area. As a consequence, impacts though negative, would be minor and long term.

A summary of Project Impacts is presented in Table 15-1.

15.3 MITIGATION OPPORTUNITIES

Although there are few significant impacts anticipated for wildlife resources within the study area due to project developments, there is some potential to implement ameliorative measures for impacts which would occur.

- Small amounts of unqulate winter range may be lost, and some consideration should be given to cost efficiency of compensating for this loss by the manipulation of remaining winter range to improve its carrying capacity. This may be accomplished by increasing the amount of cover, increasing the abundance and availability of browse species, or by a combination thereof.

- The upper terraces along Murphy Creek have been identified as one of the more important wintering areas in the valley. Management techniques that could improve this and other areas could be applied. Another potential area for improvement is the terraces of Champion Creek.

- Initial reservoir flooding should take place after July to avoid inundating the breeding efforts of birds and prior to mid-October to avoid inundating hibernating or aestivating mammals.

- Construction activities should be confined to as small an area as possible and take place during summer months when deer are not on winter ranges and are more evenly dispersed. All areas disturbed after construction should be reclaimed in order to minimize erosion and to possibly provide additional forage for ungulates.

- To compensate for the one osprey site loss and the possible loss of the second, the response of the ospreys should be monitored and if required two artificial structures should be established.

- to minimize increased pressure on deer both from hunting and harassment, all access roads should be strictly controlled during the construction period. Following construction, access roads should be permanently closed.

- The Murphy Creek till site should remain as small in area as possible. The restriction of its use to 2 months during a summer will minimize impacts. Because trucks will also be hauling only in summer, this will minimize possibilities of deer mortality as a result of collisions.

- Till and spoil sites should be reclaimed immediately following use.

TABLE 15-1

SUMMARY OF PROJECT CHARACTERISTICS AND THEIR RELATED IMPACTS ON WILDLIFE

	Construction		Reservoir Filling and Operation				
	Damsite and Reservoir Preparation	Till Site - No Mitigation	Water Level	Temperature	Wind	Access	Reservoir Fluctuations
Deer							
Numbers	-1	-3	-2	+1	-1	-2	-1
Distribution	-1	-3	-2	+1	-1	-1	-2
Habitat - Winter	-1	-3	-3	+1	-1	0	-1
Habitat - Summer	-1	-3	-2	+1	0	0	-1
Movements	-2	-3	-2	+1	-1	-2	-2
Non-consumptive Use	-1	-2	-1	0	0	+2	0
Consumptive Use	-1	-2	-1	0	0	+2	0
Aquatic Furbearers	-1	0	+1	+1	-1	0	-2
Terrestrial Furbearers	-1	-2	-2	0	0	0	-1
Aquatic Birds							
Ducks	-1	0	-2	+1	-1	0	-3
Mergansers	-1	0	-3	+1	-1	0	-2
Consumptive Use	-1	0	-2	0	0	+1	0
Terrestrial Birds							
Upland Game	-1	-2	-2	+1	-1	-1	0
Raptors	-3	0	-2	0	+1	0	0
Consumptive Use	-1	-1	-1	0	0	+1	0

0 - No effect 1 - Insignificant 2 - Minor 3 - Moderate 4 - Major

Source: Beak Consultants Ltd. (1982).

SECTION 16.0 - AQUATIC RESOURCES

16.1 INTRODUCTION

Section 16.0 summarizes the effects of the proposed development on aquatic resources and describes the consultant's recommended possible mitigation and compensation opportunities.

16.2 PROJECT IMPACTS

(a) Pre-construction Phase

Minor impacts to the fisheries resource, as a result of pre-construction activities within the study area could include:

1. Fish mortality as a result of biological studies.

2. Increased harvest due to increased fishing pressure.

3. Interference with fisheries habitat and/or activity as a result of site drilling and ancillary activities.

The impacts to fisheries resources as described above are expected to be insignificant.

(b) Construction Phase

River constriction, as a result of dam construction, may result in a velocity barrier to fish attempting to move upstream past the construction site. Upon completion of the spillway, the entire flow of the river would pass through it while the remainder of the

dam is completed. At this stage, upstream fish passage would be completely blocked. Any species that undergo an annual downstream migration would therefore be trapped below the dam resulting in an inadequacy of stocks to populate the reservoir (example walleye). Although fish movement patterns within the study area are largely undefined, available information indicates that up to 5000 kokanee migrate upstream past the damsite each year in addition to a proportion of the rainbow trout population and other sport fish.

Construction activities associated with Murphy Creek Dam would result in increased suspended sediment levels and could result in deposition downstream. The potential direct effects of this deposition include mortality; impairment of reproduction, growth and survival; and an increase in disease. Indirect effects may involve habitat modification, alteration in food source and a reduction in visibility. Aquatic organisms in the lower Columbia River are adapted to clear water conditions (turbidity generally less than 1 JTU); an addition of suspended sediments could affect fish or fish food organisms. Proper precautionary measures would greatly reduce the probability of such occurrence. Streamflow levels due to construction requirements would be limited by minimum and average flow releases currently required as part of the Columbia River Treaty.

Increased angling pressure as a result of the construction work force may lead to an over-harvesting of the sport fish populations in localized areas.

Fish mortality would occur if explosives are used in or near the channel during site excavation. The magnitude of this potential effect would be dependent upon the extent and location of explosives used, and the numbers and species of fish near the site.

Concentrations of fish are most likely to occur during spring or fall spawning and migration periods.

Construction of ancillary facilities (construction camp, access roads, borrow areas and transmission lines) would result in a minor impact to fisheries resources, providing sound engineering practices and effective erosion control methods are employed.

(c) Operational Phase

(i) Blockage of Fish Migration

A preliminary estimate of the numbers of major sport fish that presently migrate upstream past the proposed damsite is provided in Table 16-1. Although the walleye, chinook salmon and kokanee are migrant stocks originating from Lake Roosevelt (and thus dependent on the continuing abundance of these species within the lake) the spawning runs of all species listed in Table 16-1 would be blocked by the Murphy Creek Dam. Due to the small storage capacity of the Murphy Creek reservoir (hydraulic retention time of less than 2 days) and the narrow valley, a noticeable water current would exist through the reservoir. This may cause large numbers of newly hatched fry of certain species to be transported out of the reservoir and down into the river system. Downstream movement of fry is typical of many fish species that rear in lakes and spawn in tributaries (e.g. kokanee). The subsequent upstream movement of downstream displaced fish in later years, however, would be blocked by the dam.

(ii) Loss of Habitat

The transformation of an existing river into a lentic environment would greatly affect many of the aquatic organisms

living within this system. Those species adapted to running water would be replaced by species that are adapted to living in slower flowing water or a lake-type habitat. The Murphy Creek development would inundate approximately 35.7 km of the mainstem Columbia and Kootenay rivers, and 2.97 km (39 percent) of major tributory streams available to fish at reservoir elevation El. 424 m. The sections of tributary streams remaining above the reservoir level generally have a steep gradient and are rated as low or low to moderate suitability for spawning by salmonids (e.g. rainbow trout, kokanee and Dolly Varden). Details of estimated stream losses due to reservoir inundation are presented in Table 16-2. Estimates of habitat units (calculated on estimated stream area and average suitability for spawning) lost as a result of flooding at alternate reservoir levels are presented in Table 16-3. Alterations of existing hydraulic characteristics including depth, velocity and water percolation rates through the gravel substrate would contribute to a reduction in the suitability of inundated sections of the tributaries for rainbow trout spawning. The majority of spawning habitat in the mainstem of the Columbia River presently utilized by rainbow trout, Dolly Varden and mountain whitefish would also be inundated. Species such as mountain whitefish may reproduce in the reservoir by spawning in nearshore areas or near the upper limit of flooding in tributaries; however, the winter drawdown under Regime 1 would likely result in a high mortality at the incubation stage. It is doubtful if any of the fall or winter spawning species that normally spawn in the mainstem would be able to locate suitable spawning habitat.

Inundation associated with the Murphy Creek Project would severely reduce the availability of suitable rearing habitat for newly hatched juvenile life stages of salmonid species. Although inundation of the lower sections of tributaries would

increase the total amount of aquatic area available for rearing, the altered habitat would be of lower quality due to reduced cover, increased vulnerability to predation and smaller aquatic insect populations. Expected reductions in current velocity and benthic productivity within nearshore areas of the mainstem Columbia River may seriously reduce the quality of these areas for trout rearing.

Rearing habitat for species that are better adapted in slow water conditions may be greatly enhanced within the reservoir. Lake whitefish, kokanee, suckers and other coarse fish species would likely be able to adapt to reservoir conditions.

(iii) Murphy Creek Reservoir

Water quality within the Murphy Creek reservoir is predicted to be very similar to that of the present river due to the small storage capacity of the reservoir and the limited hydraulic retention time. Further details are provided within Section 17.0, Water Quality.

Due to the complexity of the interactions which may occur within the system, it is difficult to predict with certainty the biological characteristics of the proposed Murphy Creek reservoir. Based on previous studies and known characteristics of the proposed reservoir some general trends can be predicted. These include:

1. The annual drawdown of water levels within the Murphy Creek reservoir under Regime 1 would severely affect the development of aquatic vegetation communities (particularly rooted aquatic vegetation). Under Regime 2, aquatic vegetation would establish in

depositional areas along the reservoir below the 2.0 m (maximum daily fluctuation level) depth contour.

2. The rapid flushing rate of the reservoir would severely limit phytoplankton and zooplankton production. There would, however, be a continual source of phytoplankton, zooplankton and organic detritus entering the reservoir from upstream impoundments which would act as a direct or indirect energy source for organisms in the reservoir. The amount of phytoplankton and zooplankton entering the system would be the same as that entering the natural river system; thus, no significant increase in production is predicted to occur. Since river ecosystems are very effective in utilizing plankton and particulate organic material from lake or reservoir outflows, there could in fact be a decrease in the utilization of organic inputs. Nevertheless, the non-utilized material would quickly be assimilated below the Murphy Creek Dam.

3. A general shift from riverine benthic fauna to lake-type fauna would likely occur in the Murphy Creek reservoir. Extent and timing of the drawdown (operating Regime 1) of the Murphy Creek reservoir is predicted to severely reduce littoral benthic fauna.

4. Due to the aforementioned factors, fish populations within the reservoir would be primarily dependent upon food organisms entering from upstream impoundments. Acceptable methodology is not yet available to predict with accuracy the probable level of fish production within a reservoir of this type.

(iv) Murphy Creek Reservoir - Fish Species

Although it is not possible to make precise predictions about species composition and relative abundance due to the limited information regarding the responses of major fish species to impoundments in north temperate areas, probable estimates based on available information (assuming no stocking of the reservoir or fisheries enhancement) are provided below:

1. It is likely that the kokanee population in the proposed impoundment would be similar or perhaps slightly larger than would occur in the river under normal conditions. This is based primarily on the expectations that both kokanee recruitment and the abundance of major food source would be similar both with and without project (i.e. both arise primarily from Arrow Lakes).

2. Due primarily to the detrimental effects of drawdown on zoobenthos production, the substantial loss of spawning habitat and the blockage of adult spawners at the damsite, it is predicted that the rainbow trout population in the reservoir would be substantially less than the present population in the river, even though the amount of the aquatic habitat would increase.

3. The overall impact of the Murphy Creek development on Dolly Varden is expected to be small. The population that would develop in the reservoir is expected to be slightly smaller than that presently residing in the river.

4. Owing to the fact that walleye has only recently been established in the area and that the fry, being poor swimmers, would likely be carried downstream by the swift

currents, it is doubtful that walleye would be present in the reservoir area at the time of filling in sufficient numbers to create a self-sustaining population.

5. Lake whitefish would not be expected to successfully reproduce in the reservoir due primarily to a lack of spawning habitat available under Regime 1. Successful reproduction under Regime 2 is expected to be limited by daily water level fluctuations.

6. It is expected that mountain whitefish would be less numerous in the reservoir than the present riverine system due to a reduction in spawning habitat and competition for food resources.

7. Burbot would be expected to occur in moderate numbers in the reservoir because a portion of the spawning likely would occur after the proposed drawdown period and food resources for this species should be abundant.

8. Sturgeon would likely be absent from the Murphy Creek reservoir or at best, would occur in very low numbers due to a blockage in upstream movement by the dam. It is not known if sturgeon would reproduce within the area, although it is likely that a reservoir environment would reduce the suitability of spawning habitat.

9. Since they are able to adapt to a wide range of habitat conditions, large populations of suckers would likely develop in the Murphy Creek reservoir. It is probable that the large scale sucker would be the prominent species within the reservoir.

10. Due to blockage and unsuitable habitat conditions (particularly under Regime 1), the presence of carp would be unlikely. Populations of peamouth, redside shiner and north squawfish are expected to be large in the reservoir. The predatory nature of northern squawfish may result in some losses of juveniles of important sport fish.

Angler catch rates for kokanee in the reservoir would likely be similar to present levels or decline slightly due to dispersion of the population in a larger volume of water. Catch rates for rainbow trout would likely decrease in the reservoir compared to the present river (estimated to be 20 percent of the present success).

(v) Downstream Effects

Effects on aquatic resources downstream of the project damsite could include the development of a tailwater fishery and alteration in dissolved gas saturation levels. The transport of newly hatched fry or juveniles (and possibly adults) from the reservoir through the turbines, particularly during drawdown (Regime 1), would result in a concentrated sport fishery in the section of the river immediately below the damsite. In later years the extent of this fishery would be dependent upon the production of fish in Murphy Creek reservoir. Present total dissolved gas (TDG) levels in the Columbia River within the study area are high throughout much of the year due to the effects of upstream spilling. The concentration of dissolved gases are high enough to actually cause fish mortality or restrict the use of the available aquatic habitat. The Murphy Creek Project would substantially reduce total dissolved gas concentrations throughout the periods when the reservoir is at a full pool. During drawdown periods (January to May under Regime 1), dissolved gas supersaturation would occur throughout the

reservoir and in the downstream areas whenever the spillway is used as primary discharge from the Hugh Keenleyside dam. The decrease in TDG levels during summer and fall periods may significantly increase the capability of the river in downstream areas to support rearing of juvenile fish; however, the high levels during winter and early spring months may be a limiting factor and thereby reduce sport fish populations.

16.3 MITIGATION OPPORTUNITIES

(a) Construction Phase

If high velocities as a result of channel constriction during initial phases of construction prevent fish migration, temporary fish passage facilities or structures to reduce velocity and provide resting areas should be installed on the east bank of the river. During later stages of construction, trapping and trucking of the fish around the damsite may be the only feasible method of ensuring fish passage, unless permanent fish passage facilities are incorporated into the dam as part of a reservoir management plan. Temporary facilities during construction would be of marginal benefit.

It is the consultant's recommendation that strict guidelines should be written into construction contracts in order to ensure precautions are taken to control erosion and the input of sediment into the aquatic system. An environmental officer should be present on site during the construction period to ensure guidelines are followed. Guidelines should also be in place to avoid spill or discharge of waste materials from the construction site. In addition, contingency plans in the event of a spill should be prepared and agreed upon by the contractor prior to construction. All fuel storage areas, vehicles service areas and construction

camps should be located well away from the river or tributary streams. In order to reduce high mortality of fish due to underwater explosives, excavation and construction should be conducted in the dry wherever possible. If monitoring indicates that fish are abundant in the vicinity of the blasting site, charges should be buried as deep as possible in the substrate, major detonations staged in a series of successive charges to allow dispersion of most of the shock waves, and sonic or electrical shocks employed to disperse fish concentrated within the area.

Clearing of trees from the reservoir prior to inundation is recommended in order to minimize debris problems, improve navigation and to maintain aesthetic values in the reservoir. In deeper portions of the reservoir (below drawdown levels) tree stumps should be left in place to provide a colonization substrate for benthos, algae and invetebrates and to provide cover for fish. Pre-clearing should be conducted immediately prior to inundation to reduce potential erosion effect.

Angling pressure exerted by project staff should be monitored and controlled, if necessary.

The optimal timing for reservoir filling would be after the emergence of rainbow trout fry from gravel in July, and prior to spawning of fall spawning species (i.e. end of August).

(b) Operational Phase

(i) Blockage of Fish Migrations

To reduce the effects of Murphy Creek Dam on upstream migrations, passage facilities could be incorporated into the dam. Three basic methods have been used successfully to pass fish; these are:

1. conventional fishways
2. trapping and trucking
3. fish locks.

Discussions with B.C. Fish and Wildlife Branch would be required to determine the most suitable management plan for the reservoir, and related to this, the requirements for fish passage facilities.

(ii) Provision of Cover

The provision of artificial cover for fish in the reservoir would reduce predation and increase angling efficiency. After flooding, artificial shelters constructed of used automobile tires or brush bundles may be suitable for use in the reservoir depending upon the overall management scheme in the reservoir. The major potential disadvantage of these low capital cost and low maintenance cost structures is that they are hazard to navigation unless anchored in deep water (below the drawdown level).

(iii) Rate of Drawdown

To minimize the stranding of juvenile fish and fish food organisms within shallow regions the reservoir, under Regime 1, should be drawn down gradually. As a preliminary recommendation, a maximum drawdown rate 0.5 m/d is suggested as a compromise of biological requirements. The rate of refilling the reservoir, although less critical, would be most beneficial if done as quickly as possible.

(iv) Headpond Level Fluctuation

Daily and weekly variations in headpond level should be minimized to provide stable conditions for spawning and fry rearing along the shoreline.

(v) Upstream Releases

To minimize high total dissolved gas concentrations within the reservoir and downstream areas, water releases at the Hugh Keenleyside Dam during the period when the Murphy Creek reservoir is drawn down should be through the low level ports whenever possible. Studies should be implemented to investigate feasible modifications to the Hugh Keenleyside dam which could reduce total dissolved gas concentrations. Dissolved gas levels should be monitored above and below the Murphy Creek Dam during periods of spillway operation to determine if spillway release causes an increase in gas concentrations.

(vi) Reservoir Enhancement Opportunities

Preferred enhancement measures for the Murphy Creek reservoir are dependent upon:

1. the period of time during which the reservoir is operated under Regime 1,

2. physical characteristics within the reservoir after stabilization,

3. fish populations that develop naturally,

4. desired reservoir fisheries management plan.

Some of the most common or most obvious methods available that may be suitable for the reservoir include:

1. Stocking using existing hatcheries; this would not be feasible due to present commitments at existing hatcheries and reduced effectiveness of hatchery stocks in comparison to indigenous stocks.

2. Spawning facilities: the only location identified as being biologically suitable for a spawning channel is the terrace along the south side of the Champion creek approximately 0.6 km upstream from its mouth.

3. On-site incubation and rearing facility: this would appear to be the most feasible method of enhancing the sport fishery within the Murphy Creek reservoir and would be suitable for incubation of eggs and rearing of fry for both rainbow trout and kokanee.

(vii) Miscellaneous Measures

Other potential mitigation measures which have been identified, and may be suitable for incorporation to the Murphy Creek Project include:

1. Construction of fish passage facilities at natural obstructions (i.e. falls, cascades and highway culverts) on tributaries.

2. Improvement of habitat in accessible tributary reaches above the level of inundation.

3. Implementation of enhancement projects in nearby streams outside of the local study area.

TABLE 16-1

PRELIMINARY ESTIMATES OF THE NUMBER OF MAJOR SPORT FISH WHICH WOULD BE BLOCKED BY THE MURPHY CREEK DAM*1

Species	Probable Timing of Major Upstream Movement	Purpose of Movement	Estimated Numbers
Kokanee	August	Spawning	1500-5000*2
Rainbow trout	March-May year round	Spawning Feeding/random dispersion	200-750*3 500-1500*4
Dolly Varden	Unknown	Spawning/feeding	Less than 200*4
Mountain whitefish	Year round October-February	Feeding/dispersion Spawning	500-5000*4 500-2500*4
Walleye	Unknown	Feeding, possibly spawning	Less than 1000*4
Chinook salmon	May-August	Feeding, possibly spawning	Less than 500*5
Sturgeon	Unknown	Feeding, possibly spawning	50-500*4

*1 Since these estimates are based on limited data, they may be subject to considerable error; however, it was felt that an estimate should be attempted for a realistic consideration of incorporation of fish passage facilities.

*2 Assumes spawners in Norns Creek and possibly some spawners in the mainstem migrate up from Lake Roosevelt.

*3 Preliminary tag return information indicates that over one-half of the spawning population of rainbow trout utilizing Norns Creek migrate up from below the damsite. A portion of the rainbow trout that utilize other tributaries or spawn in the mainstem likely also move up from below the damsite.

*4 No data are available to base these estimates on; however, existing information in the published literature indicates that local movements likely would occur. The estimated numbers in this range seem reasonable based on abundance during the biological sampling program and from angler harvest estimates.

*5 Chinook salmon were stocked in Lake Roosevelt and have moved upstream past the damsite since they have been captured by anglers in the study area. Their abundance likely will be dependent on future stocking of Lake Roosevelt.

Source: RL&L Environmental Services Ltd. (1982).

TABLE 16-2

ESTIMATED STREAM LOSS DUE TO RESERVOIR INUNDATION AND EXTENT OF ACCESSIBLE STREAM REMAINING IN THE MAJOR TRIBUTARIES TO THE MURPHY CREEK RESERVOIR

Stream	Total Length Accessible to Fish (m)	Accessible Length of Stream Flooded		Length Accessible above El. 424 m	
		Length (m)	(%)	Length (m)	(%)
Sullivan Creek	2500	1360	100.8	2060	160.0
Horns Creek	2200	1360	61.8	840	38.2
Champion Creek	2500	440	17.6	2060	82.4
Blueberry Creek	1100	500	45.5	600	54.5
China Creek	1100	330	30.0	770	70.0
Sullivan Creek	50	50*1	100.0	80*2	160.0
Murphy Creek	600	290	48.3	310	51.7
TOTAL	7550	2970	39.3	4660	61.7

*1 The reservoir would inundate the railroad culvert which, at the present time, appears to be a blockage to fish. It is felt that after inundation fish may have access via the flooded culvert to sections of Sullivan Creek upstream of the railroad tracks. Total length of stream inundated, therefore, will be as follows: FSL 424 m = 130 m; FSL 427 m = 140 m; FSL 430 = 150 m.

*2 Net length of improved access = 10 to 30 m depending on FSL.

Source: RL&L Environmental Services Ltd. (1982).

TABLE 16-3

ESTIMATED SPAWNING HABITAT UNITS (SHU)*[1] LOST DUE TO RESERVOIR INUNDATION AND SPAWNING HABITAT UNITS REMAINING IN THE ACCESSIBLE PORTION OF THE MAJOR TRIBUTARIES TO THE MURPHY CREEK RESERVOIR (FSL = FULL SUPPLY LEVEL)

		SHU Lost by Inundation						Accessible SHU Remaining					
	Total SHU Available	FSL 424 m		FSL 427 m		FSL 430 m		FSL 424 m		FSL 427 m		FSL 430 m	
Stream	To Fish	SHU	(%)	SHU	(%)	SHU	(%)	SHU	(%)	SHU	(%)	SHU	(%)
Horne Creek	24 937	18 311	73	24 374	98	24 531	99	6 626	27	563	2	406	1
Champion Creek	6 923	1 139	16	1 686	24	2 113	30	5 784	84	5 237	76	4 810	70
Blueberry Creek	3 707	1 350	37	1 512	41	2 079	56	2 357	63	2 195	59	1 628	44
China Creek	2 670	871	33	1 003	38	1 162	44	1 799	67	1 667	62	1 508	56
Murphy Creek	1 242	600	48	621	50	766	62	642	52	621	50	476	38
TOTAL	39 479	22 271	56	29 196	74	30 651	78	17 208	44	10 283	26	8 828	22

[a1] Spawning habitat units expressed in square metres.

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SECTION 17.0 - WATER QUALITY

17.1 INTRODUCTION

Impacts of the proposed Murphy Creek Project on water quality are described along with the consultant's recommended possible mitigation opportunities.

17.2 PROJECT IMPACTS

(a) Construction Phase

Since the proposed construction method of the Murphy Creek Dam is mostly "in the dry", it is probable that most suspended solids and turbidity generated at the damsite would originate from runoff caused by precipitation in the vicinity of the construction site. In addition, erosion in Murphy Creek represents a potential source of suspended solids as construction materials would be obtained from a small area in the watershed. The turbidity and suspended solids concentration increases from construction would be greatest during diversion of the river to the left bank of the existing channel. This situation would peak during draglining below the water level on the left bank. Increased suspended solids concentrations are also predicted during the period when the cofferdams are constructed. In addition, increases in suspended solids concentrations would occur downstream of Murphy Creek Dam during periods of intense construction activity and during significant precipitation events.

(b) Operational Phase

The length of the reservoir relative to its width, the high flow and the sinuous nature of the banks would result in the waters of the reservoir being relatively well mixed. The flow of water through the reservoir would be relatively uniform throughout the water mass. Major replenishment of the reservoir would occur from upstream sources of good water quality. Separation of the water into discrete regimes and therefore different water qualities is not expected. Water flowing through the turbines and over the spillway would be of relatively uniform quality and would meet provincial water quality standards for natural waters.

Nitrogenous water quality of the reservoir would not change significantly and should represent average concentrations entering the proposed reservoir from the Kootenay and Columbia rivers. Elevated phosphorus concentrations are not expected due to the short reservoir retention time.

As the normal operating mode of the Murphy Creek Dam would be underflow through the turbines or under the spillway gates, there would be no opportunity for air entrainment and supersaturation downstream of the proposed dam would not be significantly altered from present conditions. Due to the biological oxygen demand of effluent from BC Timber a theoretical reduction in dissolved oxygen concentrations downstream of the mill of 2 to 3 mg/L could occur under existing loadings and extreme low flows. These are not likely to cause depletions below B.C. Water Quality Guidelines.

A mathematical model, developed on the basis of field studies to predict the behaviour of B.C. Timber Ltd. effluent discharge after construction of the Murphy Creek Dam, predicts that the plume under either Regime 1 or 2 would probably surface between 80 and 300 m downstream of B.C. Timber Ltd. effluent diffusers and have a

minimum dilution of between 26:1 and 110:1. Cooling of the effluent to 20°C would considerably increase these values. The effluent would not be totally diluted when it reaches the Kootenay River confluence. However, under either operating regime the reservoir should marginally improve effluent dilution and reduce ponding action in the Columbia River upstream of the confluence with the Kootenay River.

An analysis of potential thermal stratification within the Murphy Creek reservoir was undertaken. The overall implication is that construction of the dam at Murphy Creek site would not significantly affect the thermal characteristics of the Columbia River within the proposed reservoir.

17.3 MITIGATION OPPORTUNITIES

In view of the limited baseline data available for comparable projects elsewhere in B.C., it was recommended by the consultant that a comprehensive baseline and construction water quality monitoring program be designed and implemented for the proposed Murphy Creek Project in order to verify impact predictions. This program should include biweekly monitoring of flow, suspended solids, settleable suspended solids, particle size distribution, turbidity and secchi disk measurements at several upstream and downstream stations. Complementary data should be obtained for sediment transport on a seasonal basis. This would include intensive local precipitation data. This program should be initiated at least 1 year prior to the start of any construction and continue for a period of 2 years.

In order to minimize possible sediment concentration and loading, it was further recommended that the construction area at Murphy Creek Dam should be set up as a closed system in which water used in construction

would be recycled and suitably designed settling ponds built to intercept all extraneous construction effluents.

To ensure minimum downstream concentration of turbidity and suspended solids, all storm drainage from construction areas should be discharged upstream of the damsite.

(a) Operational Phase

Operational impacts on water quality, as outlined previously, have been predicted to be minimal. However, dissolved gas supersaturation would occur in the Columbia River if the Hugh Keenleyside Dam sluiceway is used from February to May each year. Downstream supersaturation could be minimized by the use of the low level ports at Hugh Keenleyside which can presently be used when the differential head between the Keenleyside reservoir elevation and the tailwater elevation is less than 9 m. If supersaturation continues to be a problem, it is possible that modification of the ports could permit their use at differentials in excess of 9 m.

SECTION 18.0 - DOWNSTREAM WATER USE

18.1 INTRODUCTION

Potential project impacts on water system, source and capacity are discussed from the standpoint of both construction activity and predicted population increases as a result of the project.

18.2 PROJECT IMPACTS

(a) Construction Activity

An assessment of the concerns identified in Table 18-1 by the consultant yields the following key conclusions:

1. There would be no impact to the existing source of supply for either the Trail or Montrose systems.

2. The Oasis and Rivervale sources may require replacement if disturbed or eliminated as a result of construction related activities.

3. There is a reasonable basis for concern with respect to the potential temporary impacts on the Cominco/Tadanac/Warfield water supply system.

4. The matter of turbidity and suspended solids levels in the Columbia River, as well as the significance relative to the Cominco operation, warrants further review.

The focus therefore is on the potential impact to the Cominco system since it is the major user of Columbia River water. The principal question to answer then, is whether the proposed method of dam construction would increase turbidity/suspended solids in the Columbia River to the point where their operating costs or production at Cominco's Trail operation is significantly affected. Present concerns expressed with respect to turbidity and suspended solids in the Columbia River relate to previous experience during construction of the Hugh Keenleyside Dam near Castlegar. In anticipation of water quality problems at that time, B.C. Hydro provided the following facilities for those waterworks systems based on Columbia River supply:

1. Water treatment plants at Tadanac and Warfield to ensure a continuous supply of filtered water acceptable for domestic purposes.

2. Two groundwater wells in Sunningdale to replace Trail's river intake.

3. A groundwater well to replace the former village of Kinnaird's river intake.

4. A pump station intake on the Arrow Lake above Hugh Keenleyside Dam to replace B.C. Timber's river intake system.

Based on a review of the available data, the maximum turbidity and suspended sediment loads within the Columbia River occurred during the period that the Hugh Keenleyside Dam was being built. The impact on Cominco operations was reportedly minimal as the existing filters and process screens were able to handle sediment loading. Since the Murphy Creek Project would be constructed mostly "in the dry" as opposed to "in the wet" construction of the Hugh

Keenleyside Dam, sediment discharge to the river would be minimized. It is therefore unlikely that the extreme levels of turbidity and suspended sediments experienced previously would be exceeded as a result of the construction of the Murphy Creek Dam.

The capability of the existing Warfield/Tadanac water treatment plants to handle increased turbidity/sediment loads could be relatively easily extended by improving the filtering system.

18.3 MITIGATION OPPORTUNITIES

With regard to the existing Tadanac water treatment plant, the capability of this facility to handle turbid water could be extended by upgrading the filtering system.

In order to provide a more complete database with respect to suspended sediments within the Columbia River it was recommended by the consultant that a monitoring program be established in conjunction with federal agencies. Monitoring stations both upstream and downstream of the damsite should be established prior to any construction activity. In addition to providing baseline information on sediment and turbidity within the river, the monitoring station would also provide a mechanism for regulating construction activity when and if required.

Table 12-1

SUMMARY OF LOCAL AREA CONCERNS OF POSSIBLE IMPACTS
ON EXISTING WATER SUPPLY SYSTEMS

Community	Existing Source(s)	Concerns
Rivervale	Surface Water	- two existing springs are fragile because they are only seepage outflows
Cominco Ltd.	Columbia River	- if river drops below a critical water level, Cominco would have to shutdown operations
		- extremely turbid river conditions could result in significant maintenance costs, and possible partial or complete shutdown of production
Tadanac	Columbia River	- treatment effectiveness of filtration plant under conditions of extreme turbidity
Warfield	Columbia River	- treatment effectiveness of filtration plant under conditions of extreme turbidity
		- public health implications of using "untreated" turbid water during periods of peak water demand
Trail	Groundwater & Surface Water	- water treatment requirements for a new Columbia River water supply system that might replace existing system
Montrose	Groundwater	- concern that capacity and/or quality of existing well could be impacted
		- future possibility of using Columbia River source for water supply

SECTION 19.0 - LAND USE AND PLANNING

19.1 INTRODUCTION

This section describes the impacts of the project on land use patterns and planning within the study area, and presents mitigation opportunities.

19.2 PROJECT IMPACTS

The direct impacts of the project would be concentrated on existing residential uses and to a lesser extent, parks and recreation areas. The effect on commercial and industrial uses would be negligible. The total number of parcels affected is estimated at 880 (including a 94-pad mobile home park) (Table 19-1). Of these estimated 880 parcels, 15 improvements would be inundated by the reservoir, 25 improvements would be located in low-lying areas between the safeline and the reservoir, and the basements of up to 80 improvements beyond the safeline would be affected by increased groundwater levels. The nature of the demand for relocated residences would be very complex and varied, taking into consideration such factors as the replaceability of existing residences, lifestyle preferences and relocation preferences.

Of the 663 ha of land area projected to be directly affected by the project, 303 ha would be inundated by the reservoir and a further 360 ha would be disturbed by construction facilities or activity.

19.3 MITIGATION OPPORTUNITIES

Specific measures recommended by the consultant to accommodate direct and indirect project impacts include:

1. Establish remedial works to maintain all existing transportation linkages (Castlegar-Robson Ferry and Broadwater Road).

2. In residential neighbourhood in east sector of Castlegar North take all measures possible to minimize the number of households to be relocated. Possibilities to be investigated further include raising of basements of existing dwelling units, as well as raising the entire area and redeveloping as a similar residential neighbourhood.

3. In Raspberry, take all measures possible to minimize the detrimental effects on the quality of the residential environment as a result of flooding of Pass Creek Parks (i.e. aesthetic impact of clearing of trees and exposed mud flats during reservoir drawdowns).

4. Further investigation would be required to identify appropriate locations for replacement of existing and potential parkland which would be lost as a result of the project.

5. The recommended criteria to be addressed in deriving an approach for accommodating project related demands for residential development include the following:

   - provide a variety of choices in terms of location, character of neighbourhood, size type and costs of housing units,

   - provide housing opportunities in close proximity to present locations of households to be relocated,

   - provide an adequate supply of all forms of housing, including single family dwellings, mobile homes and apartments,

- provide housing in a manner consistent with the land use planning objectives of local and regional government agencies, and

- recognize economics of providing services, but this should not be the overriding consideration.

6. The recommended approach to accommodating housing demands includes the following components:

   - in North Castlegar, take whatever measures are necessary to minimize the net relocation from this neighbourhood,

   - new mobile home park in south sector of Castlegar,

   - new urban single family subdivision in south sector of Castlegar, if no protective measures are undertaken,

   - new semi-rural single family subdivision in benchland area immediately south of Blueberry, if no protective works are installed, and

   - utilization of undeveloped lots in Robson, Ootischenia and Trail for housing development.

7. All existing plans and bylaws should be reviewed by the respective jurisdictions to ensure that the existing policies and development strategies are still current and accurately reflect the associated impacts from Murphy Creek Project.

8. The Regional District of Kootenay Boundary should prepare a detailed settlement plan for the rural communities and surrounding areas.

9. Compensation for necessary modifications to existing planning documents which are required due to changes in existing land use patterns as a result of the Murphy Creek Project.

TABLE 19-1

MURPHY CREEK PROJECT PROPERTY ESTIMATED IMPACTS

(With Mitigative Works)

Number of parcels impacted	880
Number of main dwellings directly affected by reservoir despite mitigation	15*1
Number of improvements in low-lying areas between the safeline and normal reservoir operating level	25
Maximum number of Improvements with potential basement impacts (located beyond safeline)	80
Maximum number of parcels requiring flow easement	355*2,3
Maximum number of parcels requiring partial acquisition (toe protection works)	195

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*1 Includes one parcel with a 94-pad mobile home park.

*2 Includes parcels with partial fill which does not impact the improvements (S. Castlegar 9, Genelle 1).

*3 Includes parcels requiring partial acquisition and partial flowage easement (Genelle 11).

SECTION 20.0 - AGRICULTURE

20.1 INTRODUCTION

This section describes potential impacts of the project on agriculture from a regional and local perspective.

20.2 REGIONAL PROJECT IMPACTS

At present, study area agriculture makes a minor contribution to total regional agricultural production. The loss of current production on potentially affected arable lands would have an insignificant impact on the region's agricultural economy.

This, however, is not entirely the case when future agricultural production is considered. The project could affect about 9 percent of all the prime agricultural land (Classes 1 to 3) found in the study area, including some of the few developable, high capability lowland sites suited to intensive horticultural production.

In a regional context, this potential impact is reduced. The maximum total area of prime agricultural land affected by the project represents less than one half of 1 percent of all prime agricultural land found in the Arrow Lakes-Columbia River sub-region and only about one-fifth of 1 percent of all prime agricultural land found in the West Kootenay region.

20.3 LOCAL PROJECT IMPACTS

(a) Arable Areas Inundated

Three major areas of possible agricultural impacts are evident in the study area: the Kootenay confluence/Brilliant area, the Champion Creek terrace area and the Birchbank terrace area. One other area of possible impact is the area to the south of Cai Creek in sub-area 6 (Castlegar Airport). Possible impacts due to the project consist largely of potential inundation of arable land. Additionally, in the area of Champion and Jordan creeks, a farm access road may be affected by bank erosion.

The Pass Creek sub-area contains a significant amount of ALR land potentially affected but, in light of present and projected non-agricultural useage, little impact is envisioned.

Tables 20-1 and 20-2 detail areas of ALR lands potentially inundated by the project. Both the agricultural capability and present land use of potentially affected areas are addressed. A total of 80 ha (Table 20-1) of ALR lands would be potentially affected at the proposed reservoir elevation El. 424 m. About three-quarters of this amount represents arable land, the greatest portion of which is high capability Class 2 and 3 land.

Very little of the arable land potentially affected is presently used for commercially-oriented agriculture. At El. 424 m only 14 ha of potentially affected lands support commercial hay production, and much of this is low intensity farming. However, as much as half the area potentially affected may have been cultivated at some time in the recent past. These areas have since been abandoned or have changed to alternate uses, such as hobby farms, rural residential areas and built-up areas. Of the remaining portion of ALR lands potentially affected, part of this area is

non-arable and most of it is forested. The non-arable lands are generally not suited to livestock grazing for reasons more related to land tenure patterns than to a lack of biophysical capability.

Although some arable lands outside the ALR could also be potentially affected by the project, generally these areas have been or will be developed for non-agricultural uses and do not represent a significant source of additional potential agricultural impact.

(b) Construction Related Impacts

Approximately 22 ha of undeveloped arable land would be disturbed by construction activity, with 19 ha capable of being returned to the resource base through reclamation.

(c) Operational Impacts

Approximately 7 km (7 to 14 ha) of arable lands, located on the edges of the reservoir, may be subject to erosion as a result of increased water levels. For the most part these lands are not being used for commercial agriculture.

(d) Agricultural Value of Affected Areas

The value (1980 terms) of present production which would be lost due to reservoir flooding is estimated to be $3,700 annually (14 ha of hay production lost).

This estimate does not include any valuation of agricultural products which may be produced in conjunction with hobby farm/rural residence holdings. Such holdings essentially constitute residential land uses and should be valued in that context.

Future agricultural production is possible in the Champion Creek terrace area, the Crown portions of the Kootenay River confluence area and the Birchbank River terrace area. Based on production estimates for representative crops, the loss of future (potential) agricultural net income from reservoir flooding is estimated to be $13,000 annually (13 ha of production lost).

This annual value represents foregone agricultural income streams that would occur on lands projected to come into production in the absence of the project. The remaining lands would generate values in alternate uses.

20.4 MITIGATION OPPORTUNITIES

The following recommendations have been suggested (Talisman Projects Inc., 1982) for consideration in order to mitigate the potential impact to agriculture as a result of the Murphy Creek Project:

1. Flood protection, by dyking or other means for some potentially inundated arable lands (particularly where such protection can be economically justified).

2. Provision of alternate farm access if existing access to the Champion creek terrace is lost due to the project.

3. Project works such as access roads, construction camps, additional borrow areas and power transmission facilities associated with Murphy Creek power, should be designed so as to minimize adverse impacts on the agricultural resource base.

4. Stabilization works for any areas of possible sloughing, increased erosion or slope instability that could potentially affect the agricultural resource base.

5. Adoption of a land acquisition policy that only secures tenure on those portions of agricultural properties or other arable lands directly required by the project.

6. A reclamation plan should be prepared and implemented for any agricultural lands used for aggregate extraction or temporarily occupied during construction, including the Billy Creek ALR area.

TABLE 20-1

ALR AREA BY PRESENT LAND USE POTENTIALLY INUNDATED (ha)

Land Use	Sub-Area 1	Sub-Area 2	Sub-Area 3	Sub-Area 4	Sub-Area 5	Sub-Area 6	Sub-Area 7	Sub-Area 8	Sub-Area 9	Sub-Area 10	Totals
Forage	N/A	N/A	-	14	N/A	-	-	-	-	-	14
Decadent Orchard			-	1		-	1	-	-	-	2
Cleared Land/ Grassland			-	1		1	1	-	-	-	3
Hobby Farm/ Rural Residential			4	-		-	-	-	-	-	4
Built-up			-	-		-	-	-	-	-	-
Other			9	20		7	7	<1	3	23	52
TOTALS			13	20		8	9	<1	3	30	80

Sub-Area 1 - Keenleyside Dam to Robson
Sub-Area 2 - Keenleyside Dam to Castlegar
Sub-Area 3 - Pass Creek
Sub-Area 4 - Kootenay River
Sub-Area 5 - Castlegar - Kinnaird
Sub-Area 6 - Castlegar Airport
Sub-Area 7 - Champion and Jordan creeks
Sub-Area 8 - Blueberry Creek - Genelle
Sub-Area 9 - Billy Creek
Sub-Area 10 - Oasis

TABLE 20-2

ALR AREA POTENTIALLY INUNDATED BY AGRICULTURAL CAPABILITY (ha)

Agricultural Capability Class BCLI	Sub-Area 1	Sub-Area 2	Sub-Area 3	Sub-Area 4	Sub-Area 5	Sub-Area 6	Sub-Area 7	Sub-Area 8	Sub-Area 9	Sub-Area 10	Totals
2	N/A	N/A	6	11	N/A	-	-	-	-	20	37
3			-	-		-	5	-	-	1	6
4			2	5		1	-	-	-	-	8
5			-	1		1	-	-	-	1	3
6			-	1		3	1	-	-	-	4
7			2	2		3	4	1	3	8	22
TOTALS			10	20		8	9	1	3	30	80

Sub-Area 1 - Keenleyside Dam to Robson
Sub-Area 2 - Keenleyside Dam to Castlegar
Sub-Area 3 - Pass Creek
Sub-Area 4 - Kootenay River
Sub-Area 5 - Castlegar - Kinnaird
Sub-Area 6 - Castlegar Airport
Sub-Area 7 - Champion and Jordan creeks
Sub-Area 8 - Blueberry Creek - Genelle
Sub-Area 9 - Billy Creek
Sub-Area 10 - Oasis

SECTION 21.0 - RECREATION AND TOURISM

21.1 INTRODUCTION

Section 21.0 describes impacts of the project on existing and planned recreational/tourism facilities within the study region.

21.2 PROJECT IMPACTS

(a) Introduction

Principal characteristics of the proposed Murphy Creek Project which would be likely to have an impact on recreation and tourism are employment, access alteration, Columbia River water level changes, flow characteristics, shore length and reservoir surface area.

(b) Resident Recreation

The Murphy Creek Project would increase area population, and alter activity participation rates and the percentage share of total user days spent in the study area - the three determinants of recreational activity levels. Sport fishing would be significantly affected. Of the total 133 400 angler days (reported in 1980) spent by residents, 26 percent occurred in the study area. As a result of the project, without consideration of mitigation measures, it is expected that the percent of total resident angler days would fall from 26 percent to 12 percent. While some angler effort would be redirected to other areas, the participation rate is expected to drop from 5.43 days per year per resident to 4.80 days.

Effects on pleasure boating would be twofold: cruising traffic would be negatively affected by placement of a dam midway in the 500 km navigable stretch of riverway; "lake boating" opportunities would be enhanced given the proximity and access of the new reservoir to both residents and tourists and the fact that the Murphy Creek reservoir would be minimally affected by log debris as compared to upstream reservoirs. The share of resident boating occurring in the study area is expected to increase from 10.6 to 18 percent (4.1 to 4.4 days per year per person).

The principal loss of swimming opportunities, due to flooding at Pass Creek Park could potentially be offset by new areas within the reservoir and protective works at Pass Creek Park. It is expected that the study area's share of swimming and overall participation rate will remain constant.

Significant new opportunities for water skiing, dingy sailing, still water canoeing and kayaking would be provided by creation of the proposed reservoir. It is estimated that the study area would gain a 10 percent share of total waterskiing (versus zero percent at present).

Although the project would lead to a slight decrease in the share of hiking/climbing activity (23 to 20 percent) it is believed that this reduction would be comprised of shifts to other locations and that the overall participation rate would not change.

From an overall perspective, scenic viewing values within the study area are not expected to be inferior to those presently afforded particularly during summer months. Due to predicted winter drawdown of the reservoir under Regime 1, the following sites would be negatively affected:

- North of lower Pass Creek
- Vicinity of North Castlegar
- South of Kootenay River
- South of Blueberry Creek
- South of China Creek
- Vicinity of Birchland

The participation rate for scenic viewing is predicted to decline only slightly.

Wildlife viewing and hunting are predicted to decline slightly because of the loss of habitat due to flooding (particularly nesting location for large bird species) and increased population pressure.

Net changes in recreational user days within the study area and the region are presented in Table 21-1.

(c) Tourism

Recreational opportunities within the study area have little influence on most tourists' decision to come to the area for holiday. The diversity of activities and opportunities in the region suggests that the project will not have a significant effect upon local tourism.

21.3 MITIGATION OPPORTUNITIES

(a) Fishing

Should site specific mitigation/compensation alternatives identified by fisheries specialists (incubation and rearing facilities, fish passage facilities and instream improvements) be successfully

implemented, it is believed that the project impact on aquatic resources would be significantly reduced. It is estimated that the study area's share of fishing would decrease from 26 percent to 18 percent (versus 8 percent without mitigation) and that the participation rate would decline from 5.52 days to 5.00 days (versus 4.60 days without mitigation).

(b) Boating and Waterskiing

To facilitate significant boating use of the proposed reservoir access, launch and facilities for boaters compatible with reservoir operation should be designed and financed in co-operation with public and private groups in the study area. Two locations are suggested; North Castlegar (Zukerberg Island) and near the dam site. Facilities should be initially designed with 25 to 30 boat slips with provision for expansion to 50 slips. Design should also attempt to accommodate daily water level fluctuations in the order of 1.5 m to 2.0 m. Escapement of logs from the pulp mill operations near Castlegar should be controlled as much as possible to minimize danger to boaters and water-skiers.

Mitigation options (which are considered to be economically feasible) for cruiser boat traffic past the proposed damsite include truck-around or elevator facilities. Capital costs for a single truck-around and launch facility would be approximately $75,000 (1/2 hour per boat) and $100,000 for a double truck facility (15 minutes per boat). This type of facility could accommodate all cruiser traffic sizes presently utilizing the river.

Boating and waterskiing are expected to increase as a result of the project even without mitigation-compensation initiatives.

Implementation of these mitigation-compensation options are estimated to result in a further increase of the study area share

of boating (presently 10 percent) to 18 percent and an increase in the participation rate (presently 4.13 days per person per year) from 4.40 days per person per year. The estimated result for waterskiing would be to increase the study area share from (presently zero) to 4 percent and an increase in the participation rate (presently 1.11 days per person per year) to 1.14 days per person per year.

(c) Swimming, Picnicking and Hiking

Providing the recreation facilities at Pass Creek Park and the ball field near the gas pipeline in Castlegar are protected, most initiatives would properly be viewed as enhancement rather than mitigation.

(d) Camping

Providing the proposed campsite development at Pass Creek Park goes ahead and is protected from flooding, no campsite development would be required for mitigation.

TABLE 21-1

OUTDOOR RECREATION IN STUDY AREA

CHANGES IN USER DAYS DUE TO PROJECT WITHOUT MITIGATION

	1988	1993	1996	2001
Fishing				
Study Area	54	-34 169	-38 485	-43 561
Other Areas	151	8 975	8 785	9 861
TOTAL	205	-25 194	-29 700	-33 700
Boating				
Study Area	17	5 990	6 409	7 933
Other Areas	143	-1 671	-3 109	-1 193
TOTAL	160	4 319	3 300	6 740
Swimming				
Study Area	27	169	0	0
Other Areas	460	2 909	0	0
TOTAL	486	3 078	0	0
Sightseeing				
Study Area	33	-5 915	-6 861	-7 785
Other Areas	240	7 746	6 861	7 785
TOTAL	274	1 830	0	0
Picnicking				
Study Area	8	50	0	0
Other Areas	201	1 343	0	0
TOTAL	209	1 394	0	0
Hiking/Climbing				
Study Area	28	-3 631	-4 194	-4 910
Other Areas	94	4 401	4 194	4 910
TOTAL	122	770	0	0

TABLE 21-1 - (Cont'd)

	1988	1993	1996	2001
Wildlife Viewing				
Study Area	8	-1 470	-1 683	-1 948
Other Areas	79	2 031	1 683	1 948
TOTAL	87	562	0	0
Hunting				
Study Area	4	-259	-297	-335
Other Areas	23	-354	-517	-582
TOTAL	26	-613	-813	-917
Golfing				
Study Area	4	25	0	0
Other Areas	202	1 348	0	0
TOTAL	205	1 373	0	0
Camping				
Study Area	-6 198	61	0	0
Other Areas	6 384	1 166	0	0
TOTAL	186	1 227	0	0
Waterskiing				
Study Area	0	863	924	1 078
Other Areas	42	-593	-924	-1 078
TOTAL	42	270	0	0

SECTION 22.0 - SOCIO-ECONOMICS

22.1 INTRODUCTION

Project impacts are evaluated in terms of population, housing, services, local and regional economics.

22.2 PROJECT IMPACTS

The assessment of the socio-economic impacts of the Keenleyside Powerplant and Murphy Creek projects was combined as the impacts are, in many cases, cumulative. Further, if the two projects proceed together, workers would have the opportunity to move from one project to another. In total, the Keenleyside-Murphy project would create 5500 person-years of employment. Local employment on the project would be high (66 percent) due to projected high unemployment rates in the study area and among local union members now working outside the area. If Murphy proceeds alone, the local share of employment would be even higher, (77 percent) reflecting its smaller construction labour force, but person-years of employment would be less.

The in-migrant labour force would have a small population impact on the Castlegar/Trail area. While most (75 percent) of the supervisory and owner's staff would bring their families and take up residence, other occupational categories would be more likely to reside in construction camps because, typically, they would only be needed for a year or less. During the peak year of construction, 1991, there would be an additional 235 permanent residents in the Castlegar/Trail area and an average of 557 in the construction camps. If Murphy proceeds alone, the average during the peak year, 1991, would be about 130 permanent residents and 260 in the construction camp.

Overall, the project would have a positive, but very small impact on the population of the study area. It would result in a deceleration in the rate of decline projected for the 1986 to 1995 period. Corresponding to the project's small population impact, the effects on municipal infrastructure and community services would also be small and could even be favourable to the extent that the project-induced population would allow these services to operate at closer to full capacity over the 1986 to 1995 period.

Expenditures on the Keenleyside-Murphy Project within the Castlegar/Trail area would initiate a cycle of spending resulting in additional jobs and incomes for local residents and businesses, in-migrant workers, and individuals and firms outside the study area. About 65 percent of these expenditures can be assigned to the Murphy Creek Project and about 35 percent to the Keenleyside Powerplant Project. When the direct, supplier-related and respending effects are combined, the project would add more than 1500 jobs to the study area economy in the peak construction year, 1991/92. This represents a 6 percent increase compared to the without-the-project projections. The unemployment rate in the peak construction years (1989 to 1993) would decrease from an average of 11 percent to an average of 7 percent as a consequence of the project. Over the total construction period (1986 to 1995), almost $141 million would be added to the personal incomes of the permanent residents of the Castlegar/Trail area. In the peak construction year, the relative impact on total personal income would also be about 7 percent. The relative impact on personal income per capita would be somewhat lower, but still highly significant. Throughout the 1989 to 1993 period, per capita income in the study area would be from 4 to 6 percent closer to the provincial average as a consequence of the project. In general, the project would have a favourable effect on the study area's economy and would help offset the effects of the employment reduction at Cominco.

In the operating phase, the Keenleyside-Murphy Project is expected to employ a total of 24 employees at the two sites. Additional employment of 30 to 40 people for a 6-week period would result from annual maintenance. Respending of income would generate up to six additional jobs in the service sector. The annual increment to the personal income of the study area's permanent residents would be approximately $900,000. This represents less than 0.2 percent of aggregate personal income projected for the area.

Because the impacts on population would be small, the effects on housing and physical infrastructure would be similarly limited. December, 1982 estimates indicate that under the 424 m alternative for Murphy Creek approximately 106 to 225 households (including 94 mobile homes) would have to permanently relocate and an additional 35 to 75 households would have to move temporarily. A relatively small number of in-migrant workers are expected to require permanent accommodation in the study area (for example, approximately 80 in-migrants will be seeking permanent accommodation in the peak year). Since the vacancy rate for rental accommodation in the area is expected to be high throughout the projection period, and since the area's housing construction sector is expected to be operating at below capacity without the project, it is concluded that permanent in-migrants and relocatees will be readily accommodated either in existing housing stock or in new houses which could be constructed without straining the area's residential construction capacity.

The effects on local government finance would be quite subtle and as such, have not been precisely quantified. In any event, the impacts would be small and are expected to be distributed among a number of municipalities. Therefore, a detailed analysis appears unnecessary.

Considering the minimal population impacts of the Keenleyside-Murphy Project and assuming that 1981/1982 levels of service are maintained,

the project is expected to have no significant impacts on most community services. The few potential impacts are:

1. There would be a slight increase in the number of school-aged children in School District No. 9 and 11.

2. The RCMP detachments in Castlegar and Trail may experience changes in their workload as a result of the construction camps.

3. If unemployed transients come to the area looking for work, demands on the local Ministry of Human Resources offices for financial assistance may be created.

Some negative social impacts of the Keenleyside-Murphy Creek project were identified. These included:

1. Negative impacts on people whose homes would be flooded (for example, stress from the disruption of moving and the loss of a valued home and neighbourhood),

2. disruption to the residents of Rivervale/Oasis as a result of construction activity (for example, noise, dust, vibration and increased traffic) and the presence of the construction camp nearby, and

3. disturbance and inconvenience to residents temporarily displaced.

There is strong local support for the Keenleyside Powerplant Project and people want it to proceed as quickly as possible so the community can obtain the employment and income benefits. There is more ambivalence toward the Murphy Creek Project because of the potential environmental impacts and the relocation of residents who live along the river bank.

Overall, the socio-economic impacts of the Keenleyside Powerplant Project combined with Murphy Creek El. 424 m Project are clearly positive. No serious negative socio-economic effects have been identified for these generation projects.

22.4 MITIGATION AND COMPENSATION OPPORTUNITIES

(a) Local Hire

At present, hiring of construction workers for B.C. Hydro projects is done through the construction trades unions. Many of these unions do not take the location of workers' permanent residences into account when matching workers with jobs. Thus, workers from outside the study area may get jobs on the project while local workers remain unemployed.

Because of the expected weakness in the study area economy, it is recommended that preference in hiring should be given to residents of the study area.

(b) Local Procurement

B.C. Hydro should develop a program to make local businesses and suppliers aware of the requirements of the project and should develop measures to maximize the participation of local businesses in the project.

(c) Liaison with Major Employers

In general, B.C. Hydro should discuss the labour requirements and timing of the Keenleyside Murphy Project with the major employers in the area with the aim of co-ordinating their major labour demands to minimize economic and social disruption in the area.

(d) Compensation to Relocated Residents

There are two main ways in which B.C. Hydro can assist potentially relocated residents: reducing their uncertainty during the pre-project approval phase and implementing a fair compensation plan for owners and renters.

(e) Liaison with Residents Living Near Construction Sites

B.C. Hydro should maintain close liaison with residents and groups in the Oasis/Rivervale area and the Balfour/Robson area to ensure that B.C. Hydro is aware of any serious problems related to the camps or disturbances resulting from construction activity. B.C. Hydro and the affected communities should work together to alleviate any problems which arise.

(f) Compensation to Temporarily Relocated Households

B.C. Hydro should develop compensation plans for residents whose properties will be altered and who will, therefore be temporarily displaced. The compensation plans will likely vary according to the nature of the alterations required, the length of time residents will be displaced, and the alternate accommodation arrangements preferred by different households.

(g) Information Regarding the Project's Environmental Impacts

As the previous section pointed out, many residents are concerned about the potential environmental impacts of the Murphy Creek Project. B.C. Hydro should make its consultants' reports on the environmental impacts of the Murphy Creek Project readily available to the public and should hold public information meetings in the local area to explain and/or clarify information about the potential impacts.

(h) Project Monitoring

B.C. Hydro should develop a project monitoring system to assess the environmental, social and economic effects of the project during construction and operation and to establish a mechanism for timely response to problems cause by the project.

SECTION 23.0 - HERITAGE RESOURCES

23.1 INTRODUCTION

Implications of the project impact upon heritage resources are described along with the consultant's mitigation and compensation recommendations.

23.2 PROJECT IMPACTS

Heritage resources within the Murphy Creek study area were inventoried and evaluated through field observation, subsurface and laboratory testing. Of a total 39 sites, 13 were identified as circular or rectangular cultural depressions, 21 as general activity sites, 4 as burial sites, and 1 and a pictograph.

Field investigations, conforming to Provincial Government Stage II requirements, were conducted throughout the entire study area in order to confirm the presence and extent of heritage resources in relationship to project components. The findings were that as a result of all project construction, 4 heritage sites of significance would be disturbed. The sites are briefly described as follows:

(a) Site: DiQj 21 Pass Creek

This is a small, possibly remnant site area that is all that remains of a larger site previously eroded by the Columbia River and Pass Creek. The projectile point forms recovered here are not at all well described in the literature for adjacent areas. A larger sample from this site might lead to the definition of a new type for the area, or might provide further information on stone

tool technology. In either case contribution to scientific knowledge would be significant.

(b) Site: DhQj 1 Brilliant

This large site has been subject to disturbance by farming activities but is still in a good state of preservation. A test sample of DhQj 1 has yielded information that shows occupation of the area from at least 4500 years ago to the present. The cultural material is a relatively undisturbed, sandy, matrix that unconformably overlies river cobbles to a depth of 150 cm. The potential for qualititative and quantitative data spanning a long period of time is great at his site. Columbia plateau burials have been fairly well described (Sprague and Birkby, 1970; Sprague, 1968, 1967; Sanger, 1968) but the potential for expansion of that data from this site is very high. In addition to the above, DhQj 1 evaluative testing recovered burials in two different localities. The burials so far recovered indicate a recent date but the possibility exists that earlier material could be encountered.

(c) Site: DhQk 5 Ferry Slip

This small site is possibly all that remains of a larger site area. A cultural component approximately 40 cm below surface is preserved from erosion due to the fact that it is beneath a clay hardpan layer. Projectile point types recovered in the test sample appear comparable to types found in the area dated ca. 2500 B.P. (Before Present). One quartz crystal microblade core was recoved during test evaluation. The position of microblades and cores in the regional sequence is somewhat ambiguous. A larger sample from this site may serve to resolve a dispute in circles regarding the occurance of microblades and cores.

(d) Site: DgQk 1 Hanna Creek

This site is located on a badly disturbed terrace. Nonetheless, the extent of the site is considerable (300 m by 50 m) and significant data could at least be quantified with a major recovery program. Projectile point types recovered in evaluative testing indicate a fairly early time of occupation for this site. the cultural material is in a farly discrete, sandy, matrix that overlies bedrock in a uniform thickness of approximately 60 cm.

23.3 MITIGATION AND COMPENSATION OPPORTUNITIES

Salvage or protection of the four significant heritage sites identified is recommended prior to disturbance by construction and/or inundation.

SECTION 24.0 - MURPHY CONSTRUCTION CAMP

24.1 INTRODUCTION

In general, impacts which could be directly attributable to the construction camps of either the Murphy Creek Project or the Keenleyside Powerplant Project have not been considered separately from other project impacts. However, due to a recommendation by the Project Impact Committee and the proximity of the proposed site of the Murphy Creek construction camp to the community of Rivervale it was considered prudent that potential impacts resulting from this spatial relationship, other than socio-economic impacts, be studied separately. This section summarizes the findings of this study and the related public consultation.

24.2 PROJECT IMPACTS

A study has identified the potential direct impacts of the Murphy Creek construction camp on the Rivervale community as visual, noise and traffic dust impacts.

It is worthy of note that selection of the proposed site was, in part, based on the results of public consultation with area residents. At a public meeting held to solicit public input into the site selection process six potential campsites were discussed. It was apparent that area residents hoped that with the camp located north of Hanna Creek, between Rivervale and the active work areas it would tend to act as a buffer zone to mitigate against direct construction activity impacts on the community.

There will potentially be visual, noise and traffic dust impacts on the Rivervale community, which could be attributable to the Murphy construction camp.

24.3 MITIGATION OPPORTUNITIES

It has been established that all services required for the construction campsite can be made available to the local area. Various options for water supply and sanitary sewage disposal have been investigated. In recognition of the need for an assured source of water and means of sewage disposal B.C. Hydro presently proposes a self-contained system with extraction of the water supply from the Columbia River, and disposal of sewage through a package sewage treatment plant with outfall to the Columbia River.

In order to mitigate the potential visual, noise and traffic dust impacts on the Rivervale community, which could be attributable to the Murphy Creek Project construction camp, B.C. Hydro proposes to:

1. Retain a 30 m wide belt of existing tree cover along Hanna Creek and the Columbia River to reduce visual intrusion and help screen noise and dust.

2. Give careful attention to filling and grading of the camp area, siting of buildings and choice of building colour scheme to reduce visual and noise impacts.

3. Selectively landscape the camp area retaining some existing trees, planting shrubs and seeding selected areas to further reduce visual impacts.

4. Develop a camp layout with direct highway access at the north end of the site to screen camp and construction traffic from the

residential area at the south end of the camp, adjacent to Hanna Creek.

5. Pave camp roads and parking areas to minimize dust raised by camp traffic.

6. Provide discontinuous perimeter road, to allow only intermittent light service vehicle traffic along the south boundary of the camp and thereby further reduce traffic noise and dust impacts.

7. Investigate possible future uses for areas of the decommissioned camp site, which are not otherwise required for operation of the Project.

8. Investigate the feasibility of joint camp and community water and sewage systems organized by the Regional District and partially funded by B.C. Hydro up to the equivalent cost of the self contained camp water and sewage systems.

9. Consult with the local residents on matters of mutual interest.

SECTION 25.0 - GROUNDWATER

25.1 INTRODUCTION

This section summarizes the potential project impacts on groundwater, and mitigation opportunities.

25.2 PROJECT IMPACTS

The major impact of the Murphy Creek Project would be to raise groundwater levels in the immediate vicinity of the reservoir. Wells which are not inundated should have higher water levels and, therefore, slightly higher capacities than before. Without mitigation measures, flooding of some basements could occur, and the operation of several on-site sewage facilities could be affected.

In almost all cases, aquifers would continue to receive recharge from the uplands and not from the river. Operation of the project would produce fluctuations in the water table in the immediate vicinity of the project which are greater in magnitude and more frequent in occurrence than those which occur presently. However, there is no reason to believe that this factor, nor the raising of the water table, would have any effect on aquifer water quality.

The aquifer at Selkirk College would probably continue to recharge from both arms (Columbia and Kootenay) of the reservoir as the elevation difference between the two arms would be negligible. The water quality study concluded that the reservoir water quality would not be significantly different from existing river water quality.

Finally, it is most unlikely that construction activities at the Murphy Creek site, including blasting, would affect the rock structure in the aquifer underlying Oasis. Therefore it is most unlikely that construction activity would affect the water quality and capacity of wells in Oasis.

25.3 MITIGATION OPPORTUNITIES

The consultants have recommended that the following actions be taken:

1. Determine the elevations of basement floors of several buildings, to make sure that they are at elevation 425.5 m or higher.

2. Continue observations at six water level piezometers in Castlegar on a monthly basis, except during peak run-off, when the observations should be more frequent.

3. Install three small diameter well points or piezometers on the Pass Creek Delta.

4. Install observation well in rock between existing rock wells at Oasis and the dam site to confirm that blasting does not affect water levels in rock wells.

5. Take regular observations of the chemical quality of groundwater pumped from the Selkirk College aquifer to monitor any changes in water quality which may result from creation of a reservoir at elevation 424 m.

SECTION 26.0 - NOISE, VIBRATION AND DUST

26.1 INTRODUCTION

A consultant report on the Murphy Creek Project has provided an assessment of noise and vibration impacts from construction activities. B.C. Hydro has assessed dust impacts.

26.2 PROJECT IMPACTS

Noise and vibrations eminating from construction activities at the proposed Murphy Creek project site have been identified as a potential source of considerable nuisance on the adjacent communities of Oasis and Rivervale.

The major potential sources of noise would be rock excavation operations (drills and compressors) and earth excavation and concreting operations (off-highway vehicles). The major potential source of vibration would be blasting. The major potential sources of dust would be vehicles travelling on unpaved surfaces and blasting.

Noise level readings of construction equipment and activities were made at Revelstoke hydroelectric construction site and elsewhere to obtain suitable input data for the noise analysis. At the Murphy Creek site field studies were carried out including measurement of existing noise levels and measurements of sound attenuation (sound decay) from the proposed site to adjacent communities. These field data, together with data available in researched literature, permitted quantitive predictions of noise levels to be made at various receptor locations in the communities of Oasis and Rivervale and subsequently to anticipate degrees of noise impact.

Construction noise, apart from blasting, would vary as the project progresses through various phases of construction. For the purpose of predicting noise impact, the major phases identified were Mobilization, Rock Excavation, Earth Excavation/Concrete, and Site Clean-up.

The main vibration impact that would be experienced in Oasis and Rivervale would be that associated with blasting. However, it was concluded that neither vibration nor noise from blasting would have any serious impact on these communities providing that sequential delay blasting techniques are used to limit the explosive charge per delay, that the number of blasts per day is small, and blasts are scheduled to result in the least possible interference with community activities.

Increased levels of dust would be experienced in adjacent communities during rock excavation, blasting, hauling and dumping operations as well as general borrow haul and construction activities on unpaved roads and work areas.

26.3 MITIGATION OPPORTUNITIES

The consultants in their report have identified five noise mitigation measures and two vibration mitigation measures. The following is a summary of the consultants proposed mitigation measures.

(a) Noise

(i) Controls on Construction Equipment

A few sources of noise would predominate throughout this construction project. During the rock excavation phase, the predominant sources would be rock drills and their associated air compressors. During the earth excavation and concrete phase, the predominant sources would be off-highway trucks

working on the left (east) bank and concrete trucks working primarily on the right (west) bank. Any noise control on these predominant sources would lower overall noise in Oasis and Rivervale.

For each of the predominant sources mentioned above, the noise level produced depends on the type, size, make, age and condition of the equipment. The noise levels that are assumed for the "no mitigation" analysis are indicative of equipment in common use today.

In the case of rock drills, the new "valveless" drills and drills equipped with air exhaust silencers are considerably quieter than the older models, as are pneumatic drills with "down-the-hole" hammers. Some hydraulic drills are also significantly quieter (those in which the engine driving the hydraulic pump is well silenced). New, silenced air compressors are also available for use with the pneumatic drills.

In the case of off-highway trucks and concrete transit trucks, noise levels have not changed dramatically over the past 6 or 7 years. Hence the variation amongst comparable trucks is fairly limited except where a truck is very old or poorly maintained. Consequently the potential benefit to be gained by specifying noise limits on trucks is not great enough to justify the extra cost which could result.

One possible approach to noise controls would be to specify a maximum permissible noise level for rock drills and compressors such that new, suitably silenced hydraulic equipment and possibly new, well silenced pneumatic equipment would meet the requirements but older unsilenced equipment would

not. No noise limits need to be specified for other equipment.

(ii) Noise Control Barriers on Site

Noise from off-highway trucks hauling waste rock from the right bank of the proposed waste dump on the left bank (in the vicinity of Billy Creek) would be perceived as a predominant source of noise by residents of Rivervale. However, by constructing a roadside barrier approximately 3 m high relative to the road surface, noise propagated from these trucks in the direction of Rivervale could be reduced, this would reduce the overall noise level in Rivervale (from all sources combined). The barrier need only be provided on that side of the road closest to Rivervale and it should be as close to the edge of the road as possible. The barrier material would be continuous, without openings and must weigh at least 5 kg/m^2. It could consist of fences, earth berms, earth cuts, or any combination of these. The proposed bridge across the river would also require an appropriate barrier along the downstream side.

The roadside barrier described above would be of little benefit to the resident of Oasis since they would be overlooking this haul road. Also, it is unlikely that other noise control barriers would be effective in reducing noise from other sources on the site. It is possible however, that once other haul routes are identified more specifically, roadside barriers would be a possible means of reducing noise during the earth excavation and concrete phase from off-highway trucks operating on the left bank and possibly concrete transit trucks. Any potential benefit from these latter barriers cannot be predicted at this time and hence should not be relied upon for reducing noise impact.

(iii) Restricted Hours of Work

Since noise during the night time results in considerably greater noise impact than noise during the daytime, significant reduction in impact could be achieved by eliminating the noisiest construction operations during the night time period. To achieve significant reductions in night time noise levels, curtailment of drilling during the mobilization and rock excavation phases and/or earth excavation on the left bank during the earth excavation and concrete phase would be the most effective.

(iv) Supplementary Ventilation or Air Conditioning for Residences

The noise impact or annoyance experienced by local residents would result largely from interference with activities carried on inside the home. Since most homes rely upon opening windows for ventilation in the summertime the noise impact assessment carried out has assumed partially open windows during at least part of the year. If an alternate means of ventilation is provided on the noise exposed side of the residence, windows could be kept closed thereby resulting in lower interior noise levels.

Air conditioning is preferable to straight ventilation because there might still be some tendency to open windows on warm summer days and nights even if supplementary ventilation is provided. Such measures would not generally be necessary on the side of the house which is shielded from the noise source since leves on the shielded side would be significantly lower.

If the measures described above are taken to ensure that windows exposed to construction noise would likely remain

closed. These would represent a significant reduction in noise impact.

(v) Additional Noise Control at Residences

Noise impact or annoyance results not only from high interior noise levels. It is also caused by high exterior noise levels, particularly during the summer when outdoor living occurs more frequently. Therefore, to achieve a further significant reduction in noise impact once supplementary ventilation or air conditioning has been provided, it would be necessary to improve both the indoor and outdoor noise environment.

The addition of conventional storm windows on the noise exposed side of a house would significantly reduce interior noise levels. Outside the house, it would be possible to provide one relatively quiet location by protecting a patio or sundeck from the construction noise by providing a solid fence or screen. This fence would require an impervious surface weighing at least 10 kg/m^2 and should be as high as practical (e.g. 1.5 m). Suitable materials, considering acoustical requirements only, would include 19 mm thick wood, 4 mm safety glass or 9 mm plexiglass. For houses oriented such that the backyard would be shielded from construction noise by the house itself, no special screens or fences would be necessary. A noise reduction could be achieved by providing both the storm windows and a quiet outdoor space.

(b) Vibration Mitigation Measures

(i) Limits to Explosive Charge during Blasting

During blasting use sequential delays and maximum charge per delay of approximately 125 kg.

(ii) Limits to Frequency and Times of Blasting

Limit blasting activities to a maximum of three per day and at regular times when least likely to interfere with residents sleep.

(c) Dust Control Measures

(i) Paving

Pave with asphalt or coat all major construction roads with an oil based emulsifier.

(ii) Watering

Water work areas where construction activities are creating dust.

SECTION 27.0 - RESERVOIR SHORELINE AND PROTECTIVE WORK

27.1 INTRODUCTION

A consultant report on reservoir shoreline conditions has established a preliminary safeline around the proposed reservoir for a normal operating level of El. 424 m assuming no protection or mitigative works to existing banks. B.C. Hydro has established criteria for protecting these banks and the properties along the banks.

Areas along the reservoir banks where protective works would be provided include banks in developed areas that would be subject to beaching and erosion, and low-lying residential and agricultural areas. Toe protective works would be provided for river banks in developed areas where economically feasible. Berm and fill protective works would be proposed in low-lying and shallow sloping areas where technically and economically feasible. Implementation of the berm and fill proposals would be subject to agreement by the affected property owners.

The following concepts have been used in the assessments of the reservoir banks, these are defined as follows:

1. Safeline

   The safeline is established from geotechnical criteria to allow for maximum bank regression. In areas where bank regression is not involved freeboard allowances govern the location of the safeline. Beyond this line the security of residents and their belongings can be reasonably assured.

2. Takeline

"A takeline is a line used to designate land which is to be purchased or restricted for future use by means of a flowage easement or other agreement." Being governed by land use the takeline can differ from the safeline. The location of the takeline is determined by property considerations for any given safeline.

3. Steep Slopes

"A steep slope is a slope that is presently steeper than 1.5H:1V." This does not imply that erosion of the slope will take place but it indicates that there is a potential for erosion independent of raising the reservoir.

27.2 PROJECT IMPACTS

1. The water level would be raised to a normal operating level of El. 424.0. This would be an increase of about 4 m at the Hugh Keenleyside Dam and would be an increase of about 12 m at the proposed Murphy Creek damsite.

2. Relatively flat beach slopes would be formed by wave and current erosion. It is assumed by the Consultant that these beach slopes would be limited to within 1 m above and 2 m below the normal operating level. This beaching effect would cause long-term regression of the existing bank slopes in most areas such that the safeline without protection would impact on or beyond the existing reservoir bank slopes.

3. In some areas the safeline without protection would impact on agricultural land, residential land (gardens), residential buildings, industrial buildings, cemeteries, railways and roads.

4. Where protection works are proposed the reservoir impact would be limited to those protection works.

27.3 MITIGATION OPPORTUNITIES

Protective Berm and Fill

A protective berm and fill could be provided in low lying developed areas, generally below El. 427, where the safeline without protection impacts on residences or roads. The protective berm and fill could be constructed to avoid the need for permanent relocation of residences by preventing flooding, beaching, regression of the banks and loss of existing facilities. Low lying areas, locally below El. 425, exist in the Pass Creek, Brilliant areas and North Castlegar.

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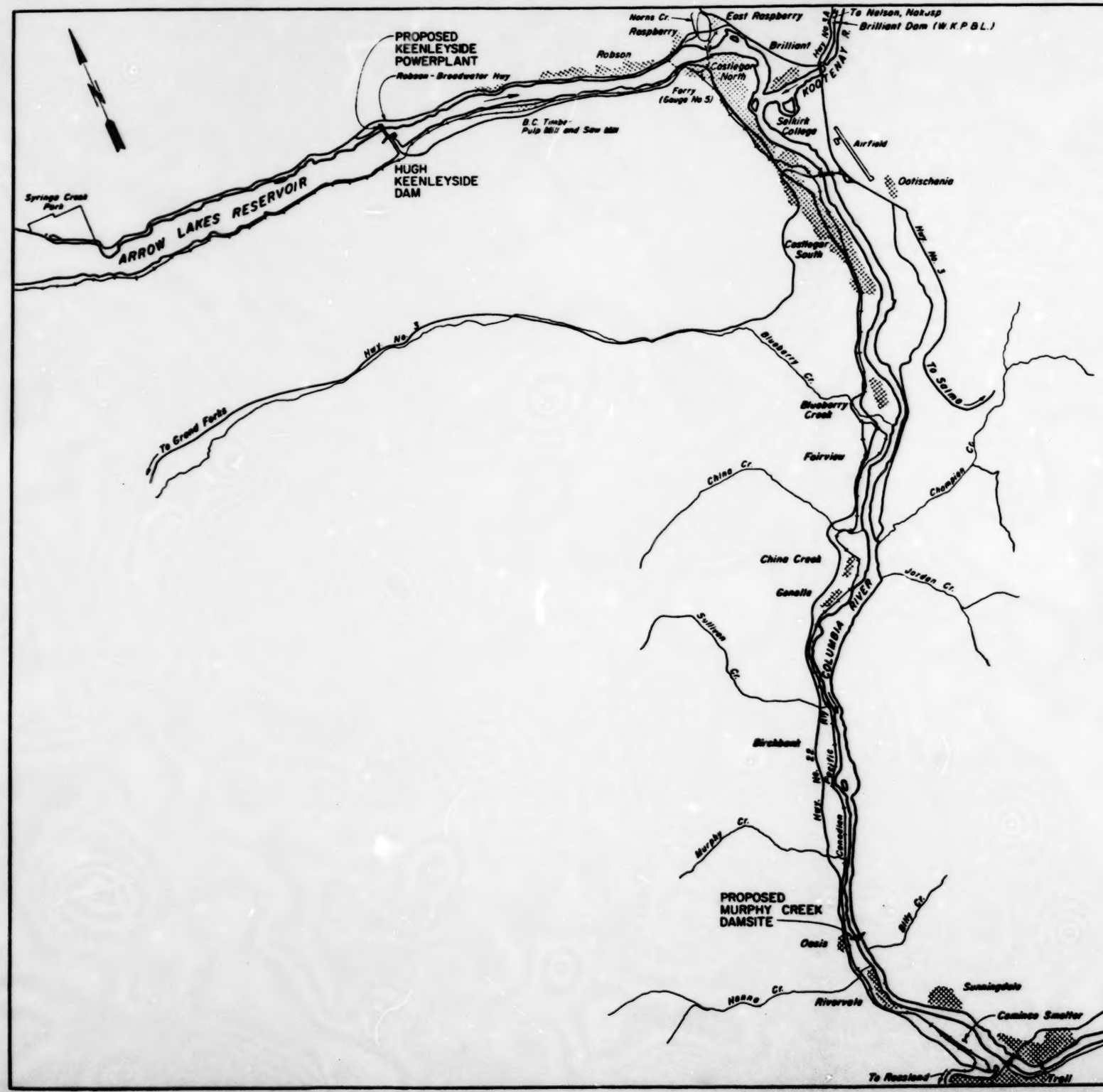

LEGEND:

SETTLED AREAS

Scale: 1000 0 2000 4000 Metres

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

KEENLEYSIDE - MURPHY PROJECT

LOCATION MAP

DATE JUNE 1983	FIG. 1-1	R
Dwn AH.	DWG No.	